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THE FUTURE ROLE OF THE ATOMIC ENERGY COMMISSION LABORATORIES

INTRODUCTION

The Joint Committee on Atomic Energy has demonstrated over the years a keen interest in the AEC laboratories. Since these laboratories are the primary development centers of the atomic energy program, it is of great importance to our Nation that there be intelligent and long-range planning for their use and development. The weapons development work performed by some of these laboratories has been of inestimable value. The continuation of the weapons development work as well as development work aimed at exploiting the "peaceful atom" is necessary to the future security and welfare of our Nation.

In view of these factors, the Joint Committee in 1959 requested a report from the AEC concerning the future role of the laboratories. The report was prepared and sent to the Joint Committee on February 12, 1960. It was entitled "The Future Role of the Atomic Energy Commission Laboratories" and consists of two volumes (app. I, p. 1).

The Joint Committee staff prepared a letter in March 1960 requesting comments on the AEC report. Comments were requested on a list of specific items. This letter was sent to industrial firms, educational institutions, AEC laboratories, State and Federal agencies, and other interested groups requesting that comments be furnished by April 30, 1960. Simultaneously a public announcement from the Office of the Joint Committee on Atomic Energy, dated March 17, 1960, was released which included a summary of the AEC report prepared by the committee staff. (See app. II, p. 154.)

This committee print consists of the AEC report entitled "The Future Role of the Atomic Energy Commission Laboratories," volumes I and II, letters of comment, and associated background material.

STATEMENT

This document is a committee compendium prepared by the committee staff and is not a committee report. It does not contain specific legislative recommendations, and is intended as a basis for further analysis aand consideration by the members of the Joint Committee and the Congress.

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THE FUTURE ROLE OF THE ATOMIC ENERGY COMMISSION LABORATORIES

A Report to the Joint Committee on Atomic Energy by the United States Atomic Energy Commission, Washington, D.C., January 1960

VOLUME 1. ANALYSIS AND CONCLUSIONS

NOTE CONCERNING RELEASE

This report has been prepared in response to a request from the Joint Committee on Atomic Energy of the Congress. It is to be treated as official use only until released by the Joint Committee.

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INTRODUCTION

This report is submitted at the opening of a decade that may well hold the gravest challenge this Nation has yet faced.

It is particularly appropriate that, at the outset of this period, the Joint Committee on Atomic Energy and the Atomic Energy Commission should be considering and planning for the future of the Atomic Energy Commission's labora-

tories, for on these laboratories, as on the other research and development institutions of the country, rests the responsibility for providing the increased understanding of the physical world and of life processes and for achieving the rapid application of scientific knowledge to practical use on which this country's place among the nations in large part depends.

Scientific and technical achievement alone will not guarantee that place; it must be merited by the preservation and fuller realization of the ideal of freedom whose many manifestations have been the basic strength of American society. But without continuous progress in the sciences and technology, the conditions of national security and material prosperity in which the ideals of freedom and individual fulfillment can be most completely attained could not be preserved.

With a challenging future ahead, and with nearly two decades of experience with federally sponsored research and development in nuclear science and technology, the opportunity to review with the Joint Committee on Atomic Energy the present work of the Commission laboratories and the Commission's future plans for them is welcome and timely.

In the last decade, as removal of security restrictions has permitted the spread of knowledge of most of the work of the laboratories, they have become recognized throughout the world for their abilities and their performance; this report, therefore, makes no attempt to summarize the contributions of these institutions to the national security, to the peaceful uses of atomic energy, and to man's understanding of nuclear processes.

In attempting to outline a pattern of activity for the decade ahead, one note of caution must be included. In any field of human activity, an attempt at a 10-year prediction is difficult at best. In scientific research and development, the uncertainties are multiplied many times over. Therefore, the forecasts included here can only be projections of what is known today; they will be certain to be changed in greater or lesser degree by tomorrow's findings. The farther the projections get from today, the more they become predictions, rather than program plans.

PLAN OF THE REPORT

The report consists of two volumes, of which the second contains supplementary materials; the Commission's analysis and conclusions make up the first volume. In part I of volume I, the report examines the Commission's current view of the appropriate roles of the Commission laboratories, the Commission's research and development objectives for the next decade, the levels of effort and trends of emphasis that will be required by these objectives, and summarizes the Commission's conclusions. Part II of volume I consists of a brief statement on each major laboratory, describing its background and current program, and summarizing the Commission's future plans for it.

Detailed discussion of weapons research and development activities has been excluded from the report because of security considerations.

DOLLAR VOLUME OF RESEARCH AND DEVELOPMENT

During fiscal year 1959 the Atomic Energy Commission spent $525 million for research and development exclusive of work on weapons. In the current fiscal year the Commission's nonweapon research and development costs are estimated at about $625 million.[1] Compared with the Commission's $525 million for research and development costs in 1959, the Federal Government as a whole spent an estimated $6.2 billion.[2] The total national expenditures, public and private, for research and development in that year are estimated at over $11 billion.[2]

The table and charts following page 3 depict the rapid rise in Commission nonweapons research and development work over the past 10 years. Weapon research and development total costs have been excluded from these data because of classification; their inclusion would tend to flatten the upward slope, since they have risen much less sharply than have other Commission research and development costs.

The rise in Commission research and development costs has been roughly parallel to the trend in the Nation as a whole; throughout the decade, Commission costs have ranged around 6 percent of the total.

---

[1] The estimated fiscal year 1960 costs used throughout the report represent the Commission's initial financial plan with a few major revisions. A number of minor changes, not reflected, have already been made, and other changes are sure to be called for as the year progresses.

[2] Source: National Science Foundation.

The importance of the Atomic Energy Commission's role in the support of research and development becomes more clear when individual segments of the multibillion dollar total of research and development are anaylzed. In the atomic energy field itself, the overwhelming bulk of development work—nuclear materials production processes; nuclear explosives for weapons and peaceful uses; reactors for civilian, military, and space exploration uses; and isotopes development—is performed with Commission funds. Of basic research in the physical sciences at the colleges and universities (excluding Government laboratories operated under contract) 20 percent was paid for with Commission funds in 1957–58. Of an estimated total of about $109 million spent by the colleges and universities in 1957–58 for basic research in the physical sciences, excluding engineering,[3] about $21.6 million was derived from Commission research contracts. In the same period basic physical science research at Commission facilities totaled $51.2 million.

In the life sciences, the Commission's role is smaller. Problems of definition make estimating difficult, but in the 1957–58 period, when total college and university costs for basic life science research were about $148 million,[3] the Commission financed somewhat less than $7 million or less than 5 percent.

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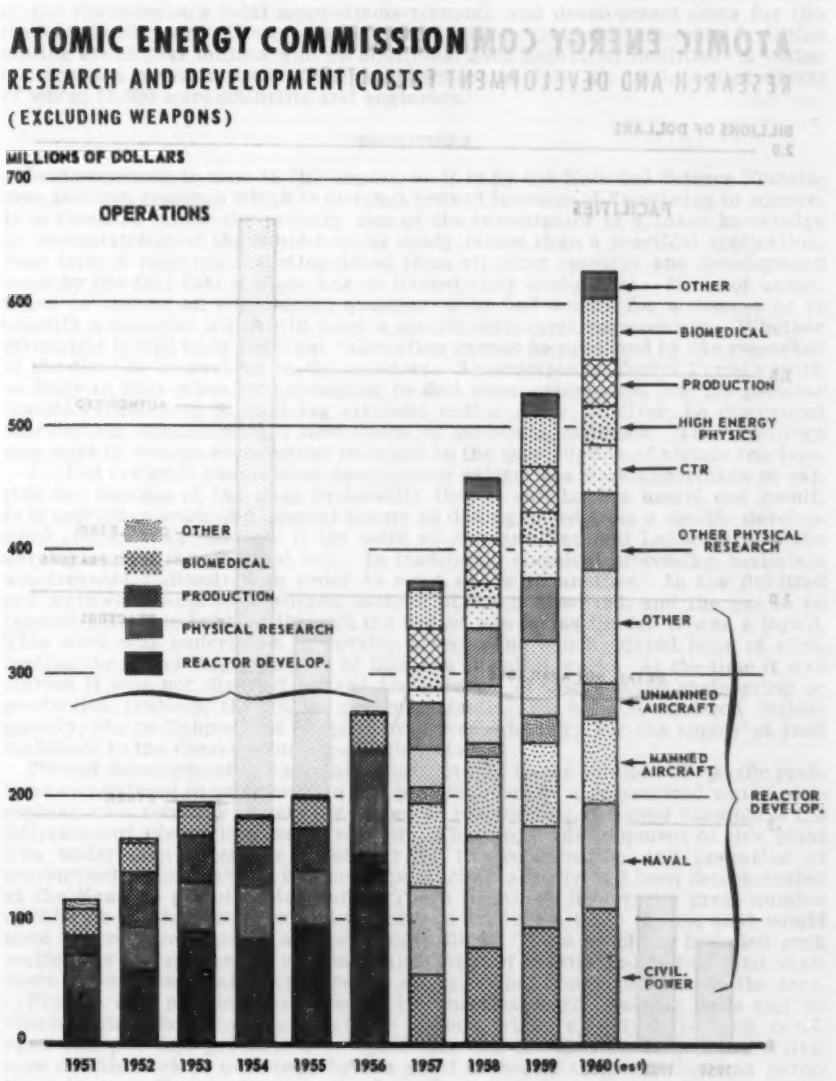
[3] Estimate based on preliminary data furnished by the National Science Foundation.

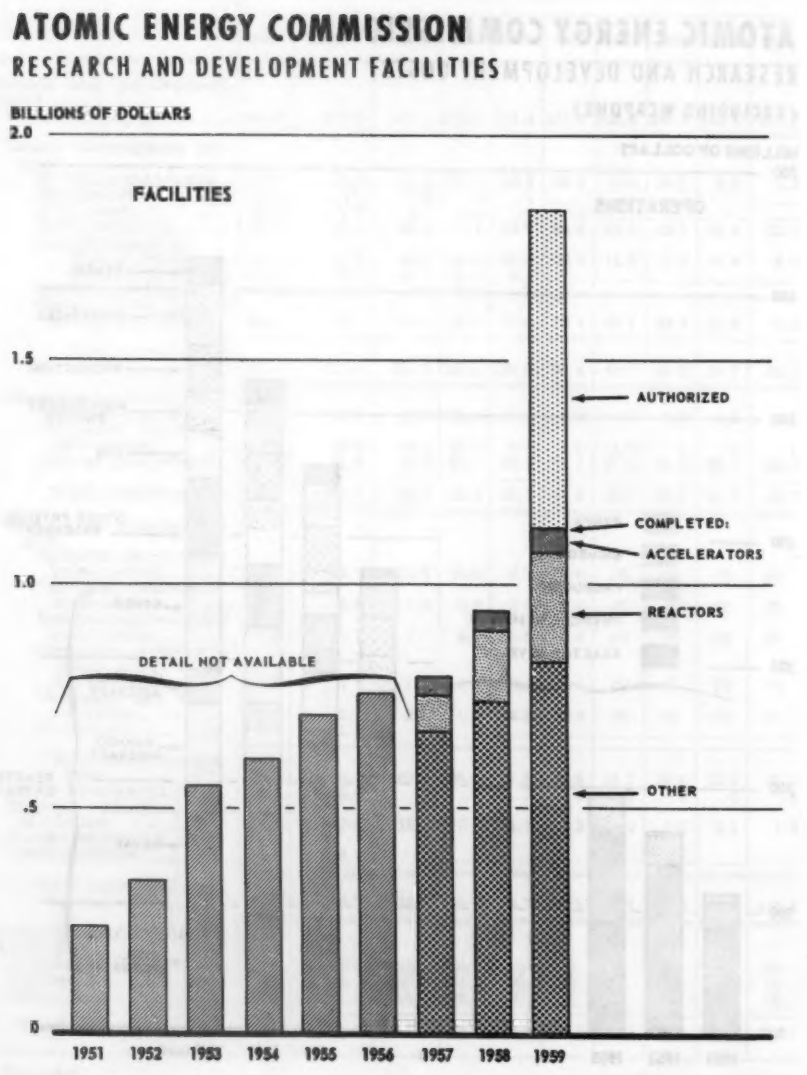
Research and development costs and facilities (excluding weapons research and development costs)—10-year trend

[In millions]

	Fiscal year									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	$36.8	$37.8	$36.6	$34.0	$33.4	$32.9	$33.6	$39.9	$43.8	$17.7
Reactor development program:										
Civilian power reactors	109.2	92.5	77.7	54.3	42.3	26.3	18.9	10.0	5.9	3.2
Merchant ship	7.5	4.7	1.6	.9	.1	------	------	------	------	------
Army power	11.9	9.0	5.4	2.9	.9	.6	------	------	------	------
Naval propulsion	86.8	83.4	90.2	71.7	40.9	26.8	25.2	32.7	26.2	22.0
Aircraft propulsion:										
Manned aircraft	63.3	66.8	62.2	68.9	44.9	22.6	14.6	17.3	10.6	5.5
Missile propulsion	32.4	22.1	12.1	12.5	4.4	------	------	------	------	------
Satellite power sources	12.4	7.7	3.4	1.5	.3	------	------	------	------	------
General reactor research and development	59.4	39.7	37.6	25.5	17.8	19.1	25.4	30.3	17.0	9.9
Total reactor development	382.9	325.9	290.2	238.2	151.6	95.4	84.1	90.3	59.7	40.6
Physical research program:										
High energy physics	33.2	25.0	17.7	16.1	11.4	7.8	7.3	7.8	5.6	5.1
Controlled thermonuclear research	36.5	27.0	18.4	10.7	6.7	4.7	1.8	.8	.2	.1
Other physical research	64.1	51.9	45.9	37.7	36.0	31.1	31.4	29.6	28.5	24.5
Total physical research	133.8	103.9	82.0	64.5	54.1	43.6	40.5	38.2	34.3	29.7
Biology and medicine program:										
Radiation effects on biological systems	16.8	14.8	12.0	10.9	9.5	8.8	[3]	[3]	[3]	[3]
Combating radiation detrimental effects	2.4	2.3	1.9	2.0	2.0	2.0	[3]	[3]	[3]	[3]
Beneficial applications of atomic energy	11.4	10.7	9.7	9.1	8.7	8.4	[3]	[3]	[3]	[3]
Biomedical problems in atomic energy operations	12.5	9.0	7.4	6.4	5.4	5.1	[3]	[3]	[3]	[3]
Dosimetry and instrumentation	2.6	2.2	2.0	1.9	2.2	2.3	[3]	[3]	[3]	[3]
Civil effects	1.4	1.2	.7	.5	------	------	------	------	------	------
Total biology and medicine	47.1	40.2	33.7	30.8	27.8	26.6	24.7	24.4	23.2	20.0
Isotope development	3.7	2.9	.3	.3	.3	.3	.3	.5	.5	.8
Training, education, and information	12.9	12.6	15.0	7.4	1.5	1.2	.9	1.3	2.1	1.6
Civilian application of nuclear explosives	7.5	2.4	.3	------	------	------	------	------	------	------
Total research and development costs	624.7	525.7	458.1	375.2	268.7	200.0	184.1	194.6	163.6	110.4
Completed plant and equipment at June 30:										
Accelerators	------	58.5	45.8	40.5	[3]	[3]	[3]	[3]	[3]	[3]
Reactors	------	238.4	167.9	84.1	[3]	[3]	[3]	[3]	[3]	[3]
Other	------	827.6	724.0	668.0	[3]	[3]	[3]	[3]	[3]	[3]
Total	------	[4] 1,124.5	[4] 937.7	792.6	753.5	707.1	616.5	548.0	338.8	233.7

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $707,800,000.


ATOMIC ENERGY COMMISSION
RESEARCH AND DEVELOPMENT COSTS
(EXCLUDING WEAPONS)
MILLIONS OF DOLLARS
700
600
500
400
300
200
100
0
OPERATIONS
OTHER
BIOMEDICAL
PRODUCTION
PHYSICAL RESEARCH
REACTOR DEVELOP.
OTHER
BIOMEDICAL
PRODUCTION
HIGH ENERGY PHYSICS
CTR
OTHER PHYSICAL RESEARCH
OTHER
UNMANNED AIRCRAFT
MANNED AIRCRAFT
NAVAL
CIVIL POWER
REACTOR DEVELOP.
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960 (est)


ATOMIC ENERGY COMMISSION
RESEARCH AND DEVELOPMENT FACILITIES
BILLIONS OF DOLLARS
2.0
FACILITIES
1.5
AUTHORIZED
COMPLETED:
ACCELERATORS
1.0
REACTORS
DETAIL NOT AVAILABLE
.5
OTHER
0
1951
1952
1953
1954
1955
1956
1957
1958
1959

Part II of this volume deals specifically with 20 of the Commission's research and development institutions, listed in the table of contents. The total cost of the research and development work to be performed at these 20 laboratories in the current fiscal year will be about $600 million. Of this amount, about $400 million will be spent in fields other than weapons, compared to the $625 million estimate of the Commission's total nonweapons research and development costs for the current fiscal year. These establishments utilize Commission-owned facilities costing about $947 million, and an additional $462 million of facilities[4] is under construction or authorized. Their employment at June 30, 1959, totaled 41,500 of whom 11,500 were scientists and engineers.

DEFINITIONS

Basic research is used in this report, as it is by the National Science Foundation, to mean research which is directed toward increase of knowledge in science. It is research where the primary aim of the investigator is a fuller knowledge or understanding of the subject under study rather than a practical application. This type of research is distinguished from all other research and development work by the fact that it alone has no immediately useful goal. It is not undertaken to answer an engineering question or to find a cure for a disease or to identify a material which will meet a specific structural requirement. Whether ultimately it will be of practical value often cannot be predicted by the reseacher at the time he is working on the problem. An example is Enrico Fermi's work in Italy in 1934 when, in attempting to find some explanation for the peculiar results experienced in inducing artificial radioactivity in silver, he discovered that certain substances will slow down, or moderate, neutrons. This discovery was later to become an essential principle in the construction of atomic reactors.

Applied research and general development categorizes work undertaken or carried out because of the clear probability that it will have a useful end result. It is applied to work of a general nature as distinguished from a specific development project. An example is the work of Argonne National Laboratory in the development of the fluidized bed. In traditional chemical processing, materials are frequently dissolved in order to react one with another. In the fluidized bed method, a solid is powdered, instead of being dissolved, and the gas to be reacted with it is bubbled through the bed of powder as though it was a liquid. This work was undertaken to develop a technique which offered hope of eliminating the use of large volumes of liquid in chemical work. At the time it was started it was not directed toward the solution of any specific engineering or production problem, though its general potentialities were recognized. Subsequently, the technique was adopted by private industry for the supply of feed materials to the Commission's production plants.

Project development includes all effort devoted to the solution of specific problems encountered in producing an end product, such as a pressurized water powerplant, or a recovery system for a specific reactor fuel. A good example is the Shippingport pressurized water reactor. The project development of this plant was undertaken after the feasibility of the construction and operation of pressurized water reactors for power production already had been demonstrated at the *Nautilus* prototype in Idaho. There remained, however, a great number of difficult problems to be solved in order to produce a large reactor that would meet the requirements of an operating utility. These problems included such matters as pumps, control systems, fabrication of maximum-life fuel, and shutdown systems necessary to assure the safety of the large population in the area.

Process and product improvement is concerned with lowering costs and increasing the efficiency of products or systems which already have been developed and put into production or operation. In the Commission, the effectiveness of this work is evidenced by the great increases in production and reductions in operating cost per unit of product that have been achieved at the production facilities.

The range of research and development work, from the basic research category to the process and product improvement category, actually is made up of indistinguishable gradations; each category shades into another. The application of the terms as defined here is subject to degrees of interpretation, and their use will always be somewhat arbitrary. Nevertheless, the general categories are valid and aid in generalizing about related kinds of work.

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[4] See vol. II for a listing of these facilities.

Commission laboratories.—There is no clear demarcation between what is called a Commission laboratory and a non-Commission installation at which a volume of research and development work for the Commission is performed. Taking either the Government investment or the annual costs as a criterion, there is a broad spectrum of institutions, with steady gradations and no sharp breaks. They range from such large and wholly Commission institutions as the Oak Ridge National Laboratory on the one hand (with completed and authorized plant totaling $180 million and annual operating costs of $52 million), to the many small groups performing Commission contract research at university campuses, using, to cite one example, a $180,000 Van de Graaff generator and incurring annual costs of $85,000. Examples of intermediate points are: the Commission's $1.7 million investment in a linear accelerator and associated equipment at the University of Minnesota, housed in a university-owned building; the Ames Laboratory at Iowa State University, with completed or authorized Commission facilities totaling $14 million but also utilizing university-owned buildings and facilities including a 70-million electron volt synchrotron; and the Lawrence Radiation Laboratory at the University of California in Berkeley, where the great bulk of the facilities ($48 million completed or authorized) are Commission owned, immediately adjacent to the campus, but where some small part of the work is done in campus facilities.

The Commission, therefore, has drawn an arbitrary line in determining which institutions would be dealt with individually in the report, using the following criteria:

1. The work is conducted in Government-owned facilities the value of which (completed or authorized) exceeds $3 million. All of the 20 Commission laboratories considered are housed in facilities that have been provided by the Commission with the exception of the two aircraft nuclear propulsion activities (CANEL and Evendale) which are housed in Air Force facilities.

2. The activity is recognized as a research and development institution as distinguished from an investment in a special piece of apparatus or an experimental facility forming a part of a larger, non-Commission complex. Again, the two aircraft nuclear propulsion laboratories are more or less exceptions to this criterion.

3. It must be engaged in research and development work as one of its principal missions, and not be devoted exclusively, or nearly so, to training, plant support, quality control, or special production assignments.

The institutions meeting these criteria, and treated individually in this study are:

Aircraft Nuclear Propulsion Facility, Evendale, Ohio.
Ames Laboratory, Ames, Iowa.
Argonne Cancer Research Hospital, Chicago, Ill.
Argonne National Laboratory, Lemont, Ill.
Bettis Laboratory, Pittsburgh, Pa.
Brookhaven National Laboratory, Long Island, N.Y.
Cambridge Electron Accelerator, Cambridge, Mass.
Connecticut Aircraft Nuclear Engine Laboratory, Middletown, Conn.
Hanford Laboratory, Richland, Wash.
Knolls Atomic Power Laboratory, Schenectady, N.Y.
Lawrence Radiation Laboratory, Berkeley, Calif.
Lawrence Radiation Laboratory, Livermore, Calif.
Los Alamos Scientific Laboratory, Los Alamos, N.Mex.
Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.
Oak Ridge National Laboratory, Oak Ridge, Tenn.
Princeton-Pennsylvania Proton Accelerator, Princeton, N.J.
Princeton Stellarator, Princeton, N.J.
Sandia Laboratory, Albuquerque, N. Mex.
Savannah River Laboratory, Augusta, Ga.
University of Rochester Biomedical Project, Rochester, N.Y.

Among the organizations excluded from detailed consideration are (1) the Atomic Bomb Casualty Commission at Hiroshima; (2) the biomedical project at the University of California, Los Angeles; (3) the Health and Safety Laboratory in New York City; (4) Mound Laboratory near Dayton; (5) the National Reactor Testing Station in Idaho; (6) the Puerto Rico Nuclear Center; (7) the accelerators at such universities as Yale, Minnesota, Carnegie Institute of Technology, Columbia, and many others.

Application of the criteria keeps the report in manageable proportions and gives representative coverage of the programs and problems that will be encountered by the other institutions.

The 20 institutions represent a wide range from the standpoint of type of work performed, size, relation to other institutions, etc. In considering their roles, the Commission recognizes several categories within the 20 laboratories.

MULTIPROGRAM LABORATORIES

The multiprogram group includes Argonne, Brookhaven, and Oak Ridge National Laboratories; Ames Laboratory, Lawrence Radiation Laboratory (Berkeley and Livermore), and Los Alamos Scientific Laboratory. Because of the close relationships between the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies, the Institute is considered along with the Laboratory. Each institution is engaged in a wide range of research and development activities, both as to the fields of science and technology involved and the type of work conducted—basic research, applied research, and general development, etc. All are operated by university contractors except Oak Ridge (operated by the Union Carbide Corp.) and there the Oak Ridge Institute provides a mechanism for interaction with the university community.

The principal common characteristics of the multiprogram laboratories is that they are integrated institutions; although they differ among themselves, each is balanced with respect both to the variety and to the relative strength of the scientific and technical disciplines as determined by the selection of the staff for interests, capabilities, and experience. As in any dynamic organization, this balance is continually shifting both within each discipline as well as in the organization as a whole, in order to keep pace with scientific and technical advances and to meet the requirements of changes in the organization's long-range objectives. Continuity, however, must be maintained if the intellectual vigor and productivity of the organization is to be preserved. Shifts in emphasis must give consideration to their impact on the total program of the organization. Discontinuities in this balance caused by the sudden elimination or the drastic curtailment of a single activity can have serious effects on apparently remote programs since frequently the value of a staff group is not confined to the activity which provides its principal support. In the case of these multiprogram laboratories, therefore, the Commision is faced with a peculiarly sensitive and complex management problem which is reflected in the character and time scale of the changes in emphasis discussed in the statements on the individual laboratories in part II.

This group could be further subdivided into three so-called national laboratories, Argonne, Oak Ridge, and Brookhaven; the weapons laboratories, since weapons development is the largest responsibility of both Los Alamos and Livermore; and the on-campus laboratories, Ames and Berkeley.

PROJECT ENGINEERING LABORATORIES

In the category of project engineering laboratories are included Evendale, Bettis, CANEL, Knolls Atomic Power Laboratory, and Sandia. In contrast to the first category, each of these institutions has one or a limited number of specific development objectives. All are operated by industrial contractors, all are conducting the work exclusively (or primarily in the case of Bettis) directed to meeting military requirements, and basic research is a minor function.

PRODUCTION PLANT LABORATORIES

This category consists of two laboratories, those at Hanford and Savannah River. Their common characteristics is their primary orientation to the development problems of the production plants which they were built to serve.

UNIVERSITY LABORATORIES

Included here are the Argonne Cancer Research Hospital, the Cambridge electron accelerator, the Princeton-Pennsylvania proton accelerator, the stellarator, and the University of Rochester biomedical project. They are distinguished from the on-campus, multiprogram laboratories by the fact that the

program of each is limited to a specific field of work. All are research oriented, and all provide research opportunities for graduate students.

The following table summarizes the categories of laboratories and the types of research and development work in which they are engaged. The column "Biological and medical research" includes both basic and applied research.

Atomic Energy Commission laboratories by type and by character of mission [1]

	Mission				
	Physical sciences and engineering				
	Basic research	Applied research and general development	Project development	Process and product improvement	Biological and medical research
Multiprogram laboratories:					
Argonne National Laboratory	X	X	X		X.
Brookhaven National Laboratory	X	X			X.
Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies.	X	X	X		X.
Ames Laboratory	X	X			
Lawrence Radiation Laboratory (Berkeley).	X				X.
Lawrence Radiation Laboratory (Livermore).	X	X	X		
Los Alamos Scientific Laboratory	X	X	X		X.
Project engineering laboratories:					
Aircraft nuclear propulsion facility, Evendale.		X	X		
Bettis Laboratory		X	X	X	
Connecticut Aircraft Nuclear Engine Laboratory.		X	X		
Knolls Atomic Power Laboratory		X	X	X	
Sandia Laboratory		X	X	X	
Production plant laboratories:					
Hanford Laboratory		X	X	X	X.
Savannah River Laboratory		X	X	X	
University laboratories:					
Argonne Cancer Research Hospital					X.
Cambridge electron accelerator	X				
Princeton-Pennsylvania proton accelerator.	X				
Princeton stellarator	X	X			
University of Rochester biomedical project.					X.

[1] In addition to missions indicated, a number of the laboratories perform relatively minor amounts of work in other mission classes.

Part I. The Research and Development Activities of the Atomic Energy Commission

Section 1. Roles of the Commission Laboratories

Twenty years ago a handful of scientists, possessed of a concept derived from basic research but which promised to be of decisive military importance, found support in the Government. To bring the atomic bomb from a concept to physical reality, it was necessary to assemble all types of scientific talents to investigate and develop radically new principles of physics, chemistry, materials, etc., and to explore and cope with the health hazards of this new source of energy. No existing institution was capable of undertaking the task.

The monumental wartime achievements of the Manhattan Engineer District are now matters of history.

In the period which followed the completion of the atomic bomb project, the country began to awaken to the vast potentialities of atomic energy. With the recognized need for energetic exploration of this new frontier, it was logical for the country to look to the skilled teams of university and industrial scientists which the Manhattan Engineer District had built up. Permanent research centers to continue the development of the military and peaceful uses of the atom and to maintain American preeminence in these fields were organized around these groups.

The soundness of this decision is borne out not only by the accomplishments that have flowed from the laboratories in the postwar period, but also by the fact that the other nations have almost invariably chosen a similar pattern for the organization of their own nuclear research and development activities. The successes of the laboratories in development have opened new fields to industry; their challenging opportunities in research have stimulated mutually enriching relations with the universities. They continue to offer even greater opportunities for complementary and mutually strengthening relationships with industry and the universities in the future than they have in the past.

The laboratories—National assets

The Atomic Energy Commission's laboratories today are vital national assets. They are uniquely strong in that each possesses a combination of staff and facilities representing a broad range of science and technology.

Together, they comprise the principal portion of the Nation's existing competence in nuclear energy research and development.

The accomplishments of the laboratories have been decisive in establishing the leading position of the United States in the military and peaceful applications of atomic energy.

The laboratories are an effective means for integrating the scientific and technical capabilities of the Nation through their complementary position with respect to the universities on the one hand and industry on the other.

They are indispensable to achieving the basic objectives set forth in the Atomic Energy Act: Development and use of atomic energy for (1) the common defense and security; (2) promotion of world peace; (3) improvement of the general welfare; (4) increasing the standard of living; and (5) strengthening free competition in private enterprise. Industry and the universities have substantial and growing shares in these responsibilities; the Commission must assure that the laboratories continue to complement industry and the universities, thereby strengthening free competition in private enterprise on the one hand, and the universities as centers of education and learning on the other.

National power and security today depend in large measure on technical advances and on the existence of the capability to make continuing advances. Rapid and sustained exploitation of atomic energy on all fronts is vital to the United States as a world power. The laboratories are able, experienced, and excellently equipped organizations constituting the major source of new fundamental facts about atomic energy; the rate of discovery and development of such facts is the very heart of achievement in the nuclear fields.

Each multiprogram Commission laboratory is organized to concentrate, at one center, varied scientific disciplines together with the requisite facilities. These disciplines support, augment, and stimulate one another. In addition to the strength of their permanent staffs, these laboratories are organized to encourage participation of scientists and engineers of universities and industry. The result is an effective tool for attacking the complexities of science and technology. The combination of these features provides the Nation with results beyond those to be expected by devoting the same talent, effort, and proportion of national resources to research and development on other bases. Thus, they supplement the technical strength of American industries and universities.

They are a principal source of new ideas for scientific programs and of suggestions and advice as to the approaches toward which major efforts should be directed.

They constitute reservoirs of organized and interrelated talent and experience which can be applied to urgent technical problems.

Commission assessment of its laboratories: Roles for the future

The past record of performance and the current strength and vitality of the Commission laboratories are outstanding. The Commission believes that the laboratories must continue to be supported vigorously. It believes that great scientific strength has been attained through the cooperation of industry, the universities, and the laboratories, and that even greater achievement may be anticipated in the future through intelligent use of all of these institutions.

The descriptions of Commission laboratories in the introduction to this report delineate four types. Each has played a distinctive role to date; each also has a distinctive role to play in the future.

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Multiprogram laboratories[5]

The Commission believes that the multiprogram laboratories must be maintained as vigorous and broad research and development institutions. They serve and stand ready to serve the Nation's technical needs in their fields of capability. They should continue to develop, build, and utilize such experimental devices and facilities as are necessary to advance this objective.

The paragraphs which follow describe the work of this category of laboratories as a whole; since the programs of the individual laboratories vary with their interests and abilities, the statements are not all equally applicable to each laboratory.

1. To continue these laboratories as useful and vital organizations requires strong programs in basic research and development in such fields as physics, chemistry, metallurgy, and the life sciences. Advancing the frontiers of knowledge in the sciences is a basic mission of the Commission and is the grist from which application-type projects are derived.

2. Nuclear weapons development is a prime responsibility of the Commission and, in turn, of these laboratories together with the Sandia Laboratory. The maintenance of a sustained effort in nuclear weapons technology is essential to the Nation.

3. An additional responsibility for which the Commission intends to rely on its multiprogram laboratories in large degree is the task of conceiving new devices for harnessing nuclear energy and new uses to which nuclear energy may be applied. Controlled thermonuclear reactions, direct conversion of nuclear energy to power applications, mobile reactors, new concepts of stationary reactors, applications of nuclear explosions to peaceful purposes, and effects of nuclear energy on chemical processes are representative examples. For any such items—whether conceived by these laboratories or assigned to them by the Commission for study and development—it is appropriate for the investigations and developments of the laboratory to be carried through demonstration of technical feasibility and far enough to provide a basis for judging probable economic worth of the concept.

4. From time to time, the Commission will utilize these laboratories and their staffs for other urgent tasks or projects of importance to the Nation.

5. These laboratories have a continuing major role in aiding the Commission in the rapid dissemination of new knowledge to the scientific and technical community. This role goes beyond simply publishing the results of their own work, important as that is to this objective. Cooperative programs with industry or providing on-the-job training for industrial personnel may be appropriate in certain situations. In others, cooperative programs with universities and the provision of assistance to higher education will serve these ends.

6. Finally, the Commission will continue to obtain from these laboratories technical evaluations and advice.

Project engineering laboratories[6]

Each of the project engineering laboratories directly supports specific military projects as its primary mission. Their current assignments fully occupy these institutions. Should program changes dictate, additional assignments will be given them as required in the national interest. Emphasis will continue to be placed on assuring that, to the maximum extent consistent with security interests, technical information developed on military programs is made available for civilian use.

Production plant laboratories[7]

The primary mission of the production plant laboratories is the improvement of processes at major Commission production centers. They will continue to be needed to support the production facilities which they serve. The Commission does not plan to develop these facilities as multiprogram laboratories; however, the Commission intends to continue to utilize the talents and facilities of these laboratories in support of its reactor development and biology and medicine programs. Such use will be secondary to their production support missions.

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[5] Argonne, Brookhaven, Oak Ridge, Ames, Berkeley, Livermore, Los Alamos.
[6] ANP-Evendale, Bettis, CANEL, Knolls, Sandia.
[7] Hanford and Savannah River.

University laboratories[8]

Each of the institutions in the university laboratory group is a special purpose research facility which supplements and is dependent upon the existence of strong institutional interests and faculty strength in related fields. The projects involved are ones for which these institutions have special qualifications and capabilities. All are of such long-range or basic nature that continued Commission support will be required.

Laboratory, university, and industry relationships

The Commission laboratories, the universities, and industry have complementary parts to play in conducting atomic energy research and development.

In the relationship between the laboratories and the universities such activities and programs as cooperative use of laboratory facilities, doctoral and postdoctoral appointments, and temporary appointments of faculty members to laboratory staffs serve to strengthen both groups of institutions. These links between the laboratories and the academic institutions must be further reinforced, and additional opportunities for interplay will be sought.

The discussion of the roles of the Commission laboratories in the earlier pages of this section does not assume that the laboratories will be assigned exclusive areas of work for which they alone will receive Government support. Research and development work warranting Commission support will continue to receive full consideration whether the proposer is from industry, a university, or a Commission laboratory. The discussion does envisage an orderly progression to industry of development projects undertaken by Commission laboratories. The Commission intends to encourage this progression and to support, through appropriate contracts with industry, such further development as warrants continued Government support.

Where feasibility is demonstrated and attractive economic potential is indicated in the laboratory, the attainment by industry of that economic promise must be managed so that there is no loss of time or technical knowledge between the laboratory and industry.

Timely and complete dissemination of information through technical reports and formal conferences are necessary tools for accomplishing the transition, but they are not sufficient in themselves. Accumulation of technical background by private industrial organizations is also accomplished in the following ways:

1. By research and development activities by private companies with their own funds or for private sponsors;
2. By Commission contracts for component development, fuel cycle investigations, conceptual design studies, etc.;
3. By conducting development work for Commission laboratories on a subcontract basis;
4. By temporary assignment of private industrial employees to Commission laboratories for work as members of the laboratory staff on development projects of interest to the industrial employer;
5. By movement of experienced personnel from laboratories to industrial employers. Such hiring has furnished industry with a substantial part of its senior nuclear development staff. Kept within reasonable bounds, it should continue to facilitate the flow of technical knowledge and experience from the laboratories to industry.

Efforts must continue to strengthen these links and to find additional means for assuring the effective flow of technology to private industry.

In the performance of their work, the Commission laboratories should utilize to the maximum extent practicable the services which industry can provide.

A research and development institution always has a choice to make among possible projects or areas of work. Its productivity and reputation, in the long run, will depend in large part on the soundness with which these choices are made. The Commission believes that the laboratories can continue to undertake new projects and work in new areas without proportionate expansion of their size. To accomplish this aim, the Commission will transfer work to others, or will bring it to a conclusion, when the Commission's needs have been satisfied, when other research performers have developed the necessary capability, or

[8] Argonne Cancer Research Hospital, Cambridge Electron Accelerator, Princeton-Pennsylvania Proton Accelerator, Princeton Stellarator, and the University of Rochester Biomedical Project.

when the work is judged to be less productive than is another project with which it competes for laboratory attention.

SECTION 2. OBJECTIVES

The broad objectives of the Commission's research and development program, which the laboratories are a major factor in executing, are stated in the Atomic Energy Act. They stem from the national atomic energy policy:

"the development, use, and control of atomic energy shall be directed so as to make the maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security; and

"the development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise."

To effectuate this policy, section 3 of the Atomic Energy Act of 1954 establishes these general objectives among others: The encouragement of maximum scientific and industrial progress, the encouragement of widespread participation in the development and utilization of atomic energy for peaceful purposes, promotion of the common defense and security, and making available to cooperating nations the benefits of peaceful applications of atomic energy. Out of these general missions have been delineated the following objectives for research and development in each of the principal program areas:

Materials supply program

In the fields of raw materials, source materials, and special nuclear materials, the objectives of development work can be stated quite simply:

1. To assure adequate supplies;
2. To reduce costs by developing more efficient production and processing methods.

The substantial process development program formerly carried on in the raw materials field has been discontinued as an adequate supply of ores and concentrates has been assured. Commercial procurement has placed on private industry the responsibility for improvements in processing methods.

In source and special nuclear material manufacture, development programs will continue to be carried out with the objective of continuing the trend of increased productivity and economy in production operations that has characterized these activities since their startup. There are no requirements evident today that will call for the development of major new production techniques or facilities beyond those currently underway.

Weapons development

Stated generally, the weapons work is aimed at the development of additional types of weapons; improved and more efficient designs, and improved methods for weapons production, storage, and maintenance.

Maritime reactors

The merchant ship program has as its major Commission objective the development of lightweight, compact nuclear plants, capable of remote operation, that can successfully enter commercial competition with conventional vessels. Supporting this primary objective are these subsidiary aims:

1. To develop operating and maintenance techniques for the NS *Savannah* and to establish a pattern for the servicing of future nuclear merchant ships;
2. To cooperate with the Maritime Administration and furnish technical assistance in securing acceptance of nuclear merchant ships in unrestricted domestic and foreign commerce.

Special purpose reactors

The broad objective in the field of special purpose reactors is to provide reactors designed and developed to meet specific service uses determined by the Department of Defense and the National Aeronautics and Space Administration. The types include reactors for the propulsion of a variety of naval vessels, manned aircraft, rockets, and ramjets; stationary powerplants for a wide range of sizes and field uses; and small auxiliary power sources.

1. *Naval reactors.*—

(*a*) To continue the development of propulsion units for applications ranging from small submarines to large aircraft carriers.

(*b*) To investigate and develop improved types of propulsion systems.

(*c*) To obtain longer core life to the extent that such development will benefit operating naval propulsion plants.

2. *Manned aircraft.*—

(*a*) To determine the feasibility and performance characteristics of direct cycle and indirect cycle plants short of operation of ground test prototypes.

(*b*) To run a ground test of a militarily useful, complete aircraft propulsion system as soon as technical development permits.

3. *Unmanned aircraft.*—Present objectives are limited, in both the rocket propulsion and ramjet systems, to a ground test demonstration of feasibility within the next several years. As that goal is approached, objectives for flight testing will be established.

4. *Auxiliary power.*—This program is directed toward the development of lightweight, long-lived nuclear auxiliary power sources for special applications, including isotopically fueled units as well as reactors.

5. *Military powerplants (Army power reactors).*—This program, the so-called Army power reactor program, is directed toward development of military nuclear power systems other than for naval vessel propulsion and air and space vehicle applications. Research and development objectives are:

(*a*) To develop a family of nuclear powerplants in the power range of about 100 kilowatts-electric up to 40,000 kilowatts-electric for all three military services.

(*b*) To increase power and core life.

(*c*) To develop simpler and more rugged components.

(*d*) To make plant operation as nearly automatic as possible and reduce crew size.

(*e*) To reduce onsite construction time and costs.

(*f*) To improve mobility.

Civilian reactors

The objectives of the civilian nuclear power program are to—

(*a*) Reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within 10 years.

(*b*) Assist friendly nations now having high energy costs to achieve competitive nuclear power costs. This assistance is to be extended mainly through clearly defined programs of cooperation.

(*c*) Support a continuing long-range program to further reduce the cost of nuclear power in order to increase the economic benefits and extend these benefits to wider areas.

(*d*) Maintain the U.S. position of leadership in the technology of nuclear power for civilian use.

(*e*) Develop breeder-type reactors to make full use of the nuclear energy latent in both uranium and thorium, recognizing that uranium 235 alone may not be sufficiently plentiful to meet the long range needs.

Additional objectives in the civilian reactor field are the development of reactors for uses other than generation of electricity, such as materials testing, production of process heat, and advanced types of research reactors.

Physical research

The Commission's objectives in physical research fall into two groups: research in areas directly related to the development of practical utilization of nuclear energy and the more long-range objective of increasing human knowledge of the nature of matter and the physical universe. Work in the first category is supported because of its potential contribution to other primary missions of the Commision; work in the second category is itself one of the primary missions.

Few people question the need for the United States and the rest of the free world to pursue a vigorous and effective program of basic research. Exploration of the scientific frontier is not only a desirable objective for its own sake but has become a vital necessity to this Nation in its efforts to maintain America's leadership in scientific advancement.[9]

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[9] Physical research program: Report of the Subcommittee on Research and Development to the Joint Committee on Atomic Energy, 85th Cong., 2d sess., August 1958.

Goals and objectives in direct support of the Commission's developmental responsibility include:

1. Providing the nuclear technologist and power engineer with information on nuclear constants and fundamental dynamic data for all nuclear interactions that influence reactor design and operation;

2. Studying the elements and isotopes of interest to the atomic energy, program, their chemical and physical properties, and methods of separating them;

3. Determining chemical and metallurgical facts in fields related to feed materials and fuel processing;

4. Providing fundamental information, by studies in the fields of solid state sciences, high temperature chemistry and corrosion processes, on the the properties and behavior of matter under normal conditions as well as under extreme conditions of temperature and radiation, so as to lay a firm foundation for increased engineering efficiency in nuclear power production.

The second major category of objectives in physical science research is that of encouraging scientific progress—"to assist in the acquisition of an ever-expanding fund of theoretical knowledge." [10]

This work in basic physical sciences is supported with the recognition that the greatest applications of science have come from investigations undertaken with no thought of utility. The aim is to maintain the United States in the forefront in nuclear science—not just for purposes of national prestige, but because continuous rapid expansion in technology must be fed by constant input of new, fundamental knowledge.

The fact that economic use, in one form or another and at one time or another, may ultimately come from basic research is not sufficient incentive for industry in general to finance such work on a large scale. Clearly, the pace of application has quickened—41 years elapsed between the discovery of electromagnetic induction by Faraday in 1841 and the completion of the first electric generating station in 1882; less than 15 years passed between the discovery of uranium fission by Hahn and Strassmann in 1939 and the large scale production of power in the submarine thermal reactor in 1953.

But the lag is still too long and the outcome too incalculable for industry to be willing to support basic research on a large scale. Because of the limited financial resources of the universities, it remains for the Government to contribute an important segment of the funds needed to support basic research. In administering this mission the Commission—

1. Supports fundamental research aimed at identifying and understanding the subnuclear particles and at the acquisition of an improved understanding of the nature of the nucleus and its binding forces;

2. Supports basic studies of nuclear phenomena, especially with respect to fundamental particles, their properties, their interactions, their transformations, and their role in nature;

3. Supports studies of the basic properties of materials—chemical, physical, metallurgical;

4. Supports studies of basic and applied mathematical techniques and the development of computers to make effective use of such data.

This work is carried out largely at the Commission laboratories and at the universities. As Commission support has grown during the last decade, the proportion of such work carried out at the universities has increased more rapidly than has the basic research at the laboratories, a trend that is expected to continue.

In the course of supporting basic physical science research, other important objectives sought after are: strengthening the applied fields by the current flow of ideas and the free point of view contributed by the basic researchers, and attracting imaginative and productive minds to the field of atomic energy problems.

Controlled thermonuclear research

The controlled thermonuclear program has as its ultimate objective the develment and demonstration of a system for the economical production of power from nuclear fusion reactions. This goal probably cannot be attained during this decade. The current, intermediate objectives of the work are, in sequence:

1. Reaching the ignition energy with a time of confinement sufficient for proper study of the thermonuclear plasma; and

[10] Atomic Energy Act of 1954, sec. 31(a).

2. Proceeding toward the development and construction of a net power producer.

The difficulty of the task makes it essential that the Commission laboratories attract and retain in this field a number of brilliant minds, to increase the chances of invention of novel devices which might be capable of thermonuclear power production.

Biology and medicine

It is imperative that an agency whose operations involve the production and handling of millions of curies of radioactivity have an aggressive research program directed to (1) defining the hazard in order to assure that radiation protection standards will be as realistic as possible, (2) developing methods of controlling the hazard, and (3) developing methods of treating and counteracting radiation injuries. No other agency in the Federal Government is so preoccupied with radiation safety as is the Atomic Energy Commission nor has as its principal biomedical responsibility a research program geared to attacking this problem.

In the biomedical research field the Commission has a further responsibility to develop information on the civil effects of nuclear weapons in a form which is readily useful to the Office of Civil and Defense Mobilization. Finally, as in other research and training activities of the Commission, it must provide leadership in the biomedical sciences for the exploration of the peaceful uses of nuclear energy, both here and abroad.

The objectives toward which the biomedical program has been directed since its inception are:

1. To exploit the use of nuclear radiations and of radioactive materials in studies of basic biological processes, with emphasis upon those recognized as being especially urgent in the interest of human welfare. In the conduct of basic work in the life sciences, considerations identical to those outlined above for the physical sciences enter equally strongly;

2. To increase knowledge of the biological effects of radiation, both from the point of view of empirical relationships between radiation dose and radiation effect and from the point of view of understanding the mechanisms by which radiation injury is produced, and to provide basic information to those concerned with developing radiation protection standards;

3. To obtain information useful in the control of biological hazards of radiation, either through minimization of exposure or protection against biological effects;

4. To develop information of a toxicological nature on those chemicals unique to the atomic energy program or being used in the program in unprecedented amounts, where existing information is inadequate for industrial hygiene needs;

5. To improve and develop techniques for the use of radiations in medical diagnosis and therapy;

6. To develop and encourage the use of radiations and of radioactive materials in agricultural research.

Peaceful nuclear explosives (Plowshare)

The work on the Plowshare program is in its early stages. Its objective is to develop methods for utilizing nuclear explosions for peaceful purposes, including the design and development of nuclear devices to serve specific applications such as mining and excavation.

Isotopes development

Radioisotopes and the physical principles by which they are used constitute an undeveloped resource for supporting scientific and engineering progress. While radioisotopes have been available and the basic principles of use known for the past two decades, their broad application is, with limited exception, relatively unexploited. The isotopes development program seek to (1) fill the gap between basic and applied research, (2) reduce the time lag between conception of a new principle and its practical application, and (3) develop a broad technological base for the exploitation of radioisotopes and radiation in important areas of the national economy including industry, agriculture, medical products, and research. To achieve this broad development of radioisotopes and radiation technology, contracts and other arranagements have been undertaken with several geographically distributed university centers, research laboratories, Commission laboratories, a limited number of industrial organizations, and other Government agencies through cooperative agreements.

The prime objectives of the isotopes development program are to—

1. Advance radioisotope and radiation technology sufficiently to encourage potential users to develop routine and economically feasible applications with ultimate benefit to the national economy and welfare;
2. Accelerate the early realization of the potential contribution of radioisotope and radiation applications;
3. Make an important contribution to U.S. leadership in the peaceful uses of atomic energy;
4. Stimulate private participation in the production and marketing of radioisotopes;
5. Provide isotope technology training, not otherwise available, as required for widespread use of radioisotopes and radiation in science and industry.

Training

The close relation of training to research and development activities and its importance to the necessary production of nuclear scientists and engineers make it desirable to discuss the training objectives briefly. In recognition of the shortage of training facilities in nuclear energy, the Commission and the laboratories have developed a training program designed to provide trained personnel in numbers adequate to meet the future requirements of the national nuclear energy program. The program has not neglected requirements on an international basis, including commitments to the International Atomic Energy Agency in fulfillment of Commission responsibilities. Training objectives include:

1. Providing opportunities for undergraduate, graduate, and postgraduate study in the scientific fields within the scope of the Commission programs, utilizing facilities not available on university campuses. Close liaison is maintained with the universities in the area; for example, graduate students engaged in study at a Commission laboratory work under a cooperative arrangement between the laboratory and the university from which they plan to receive their degree;
2. Offering university faculty members up-to-date instruction in nuclear technology. Summer institutes are used to bring faculty members current on developments in reactor and reactor-related technology;
3. Providing practical on-job training for fellows working under special Commission fellowships—industrial medicine, industrial hygiene, and health physics—and for technical personnel of industrial organizations;
4. Meeting special needs on an ad hoc basis. Examples include (*a*) the training of employees to operate new plants (such as Savannah River) and (*b*) the International School of Nuclear Science and Engineering.

Argonne's International School is a good example of a program run in cooperation with the universities until they were prepared to take on the education responsibility as a part of their normal curriculum. That point now having been reached, Argonne's activity is being reoriented, as the International Institute of Nuclear Science and Engineering, to offer advanced graduate and postgraduate training to scientists and engineers, largely through work in the laboratory's research and development programs.

Probability of change

Clearly, the more specifically that objectives are stated the more probable is it that they will be changed in the period under consideration. However, the objectives outlined above are valid against which to evaluate the magnitude of the research and development program facing the Atomic Energy Commission for the next 10 years and the roles of the laboratories in carrying out that program. There are four areas in which unforeseen developments may have particularly significant effects on the course and volume of work projected.

The first area is the field of weapons development where programs may be influenced by international agreements relative to disarmament.

The second area is the development of peaceful applications of nuclear explosives. This work is in so early a stage of exploration that the character and extent of future development work will be determined by the results of investigations and demonstration shots in the early years of the decade. The outcome of discussions on a prohibition of nuclear detonations is an imponderable in this area as well.

In the third area, controlled thermonuclear research, the future course will depend strongly upon results obtained from experimental programs now under

way and on the possible invention of new systems and devices. Currently unexpected successes or failures could result in marked modification of the detailed objectives.

The fourth area is production process development and support, where the level of effort will depend in part upon international agreements and governmental decisions on disarmament and weapons production.

SECTION 3. FORECAST OF PROGRAM TRENDS

In relatively few cases is it possible to measure quantitatively the effort or cost that must be expended in carrying out objectives stated in the preceding section. In most cases, a judgment must be formed as to the desirable effort and expenditures, related wherever possible to present levels.

The Commission has examined each of its programs, and those of its major laboratories, to determine (*a*) what functions are expected to require more effort in the next 10 years than at present; (*b*) what decreases may be expected and what tasks will be completed; (*c*) where present levels seem appropriate; (*d*) what new fields might develop; (*e*) what functions might more appropriately be discharged by other Federal agencies; and (*f*) which ones no longer need Federal support.

The results of this analysis follow:

Production process improvement

Over the last 10 years costs for production process improvement have been as follows:

Fiscal year:	*R. & D. costs (in millions)* [1]	Fiscal year—Continued	*R. & D. costs (in millions)* [1]
1951	$17.7	1956	$33.4
1952	43.8	1957	34.0
1953	39.9	1958	36.6
1954	33.6	1959	37.8
1955	32.9	1960 (estimated)	36.8

[1] Equipment costs are excluded from research and development costs throughout this report.

The level of effort expended for production process improvement has in the past been directly related to the scope of the production program. As new requirements for materials developed, in many cases resulting in the construction of major new installations, effort was increased to permit attainment of the production objective with the greatest economy and safety. With the exception of the new production reactor now under construction at Hanford, current activities are largely directed toward improving the productivity and economy of the existing facilities, with some effort allocated to development of processes for the production of minor amounts of new products. Barring any major change in production objectives, some reduction in the level of effort will be possible during the next several years. While continued improvement in economy is expected, it probably will not be of the same magnitude as that achieved in the past; consequently, it would not justify an unchanged level of development effort. Technical assistance will continue to be required to support the operating plants and to solve critical operational problems as they occur.

Weapons development

There remain many avenues of nuclear weapon research and development which promise designs that could materially improve our military capability, and, unless a positive disarmament program is achieved, weapons development will continue to receive the highest priority at the weapons laboratories.

In order to estimate the progress which can be made between 1960 and 1970, it is well to recall a past period of the same length, the period extending from 1948 to 1958. During that period, weapons research, development, and testing were designed to fulfill, and did fulfill, the following purposes:

1. The development of successive designs using less material and, therefore, increasing the defensive strength of the United States in terms of the amount of material available.

2. The development of designs of smaller configuration and lighter weight with the objective of providing weapons which can be more readily and effectively used.

3. The development of high yield thermonuclear weapons. This development has been of vital importance to our striking force and to its capability to deter aggression.

4. The development of warheads for missiles designed to defend our populations and important installations against enemy attack.

5. The development of weapons of high yield but lower production of fission products. Further progress toward this objective will make it possible for us to have weapons with greatly reduced radiological hazard (fallout).

In summary, weapons research and development can be expected to remain at a high level of effort during the next 10 years unless an effective disarmament program is achieved.

Maritime reactors

Costs for the Commission's research and development under the maritime reactors program have been—

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1956	$0.1	1959	$4.7
1957	.9	1960 (estimated)	7.5
1958	1.6		

The Commission's role will continue to be directed toward development of systems particularly adapted to merchant ship propulsion. As presently conceived, the cost of the Commission's share in research and development activities is not expected to rise substantially from the current level.

Special purpose reactors

The following table shows the trend of total costs for reactor development for the special purpose reactors—naval, manned and unmanned aircraft, auxiliary power systems, and military powerplants. Each is discussed separately below.

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$27.8	1956	$91.4
1952	37.1	1957	157.5
1953	50.0	1958	173.3
1954	39.9	1959	189.0
1955	50.0	1960 (estimated)	206.8

Reactor development work for the Department of Defense and for the National Aeronautics and Space Administration is conducted in response to requests from these agencies for the development of nuclear power sources for specific applications. Since firm requirements cannot be provided by these agencies for power sources over a period well beyond that covered by this report, the Commission's projections for these areas are based on the best judgment of its staff.

Naval reactors.—Commission development costs for naval reactors in the last 10 years have been—

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$22.0	1956	$40.9
1952	26.2	1957	71.7
1953	32.7	1958	90.2
1954	25.2	1959	83.4
1955	26.8	1960 (estimated)	86.8

It has been less than 5 years since the *Nautilus* first went to sea. The successful completion of the *Nautilus* opened a whole new technical field for development and exploitation. This field will continue to reveal new possibilities for the foreseeable future in nuclear ship propulsion. However, a gradual reduction in the level of effort on naval reactor development is expected over the next 10 years.

Manned aircraft.—Costs incurred in Commission research and development for manned aircraft propulsion over the last 10 years have been—

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$5.5	1956	$44.9
1952	10.6	1957	68.9
1953	17.3	1958	62.2
1954	14.6	1959	66.8
1955	22.6	1960 (estimated)	63.3

Effort at a level slightly above the present is expected for the next 3 to 4 years. A further increase will be required when the ground test program enters the heavy hardware phase. Assuming success in the ground test, continued increase in activity will be required in preparation for flight test. In addition, continuing investigation of advanced concepts for manned flight will be maintained throughout the period.

Unmanned aircraft.—Costs since the inception of work on unmanned aircraft propulsion have been—

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1956	$4.4	1959	$22.1
1957	12.5	1960 (estimated)	32.4
1958	12.1		

Both the rocket and ramjet programs are currently geared to feasibility ground tests which are scheduled for accomplishment during the next few years. Costs for these programs may be expected to increase substantially when full scale ground test prototypes enter the procurement stage.

Auxiliary power systems.—The rapid expansion in work on auxiliary power systems is indicated by the following tabulation:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1956	$0.3	1959	$7.7
1957	1.5	1960 (estimated)	12.4
1958	3.4		

The Commission's role in the development of radioisotope-powered units is expected to decrease since devices of this nature, being relatively small and cheap, should be of such interest to industry that product improvement will be privately supported. In the case of small reactors for auxiliary power, on the other hand, it appears that there will be a large number of requirements placed upon the Commission for development of units of increased power level for a variety of military and space applications. Accordingly it is anticipated that the Commission's role will increase during the next 10 years from the standpoint of both variety of applications and scale of development effort. Although a number of reactors will undoubtedly be brought to the point where industry will become interested in their further development, manufacture, and marketing, the variety of possibilities in this area and the need for costly research and development facilities will probably require the Commission to continue an expanding program in the development of power sources to meet new requirements. Despite the anticipated decrease in Commission support of radioisotope-powered units, it appears that the level of the program as a whole will rise.

Military powerplants (Army power reactors).—Research and development costs on Army power reactors have been:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1955	$0.6	1958	$5.4
1956	.9	1959	9.0
1957	2.9	1960 (estimated)	11.9

This program is expected to continue to expand as necessary to respond to firm Department of Defense requirements.

Civilian reactors

The substantial and continuous growth of research and development costs for the civilian reactor program, including nuclear technology, reactor safety, and general support, is brought out in the following data on cost trends:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$12.8	1956	$60.1
1952	22.6	1957	79.8
1953	40.3	1958	115.3
1954	44.3	1959	132.2
1955	45.4	1960 (estimated)	168.6

The achievement of the objectives of the civilian power reactor program will require a continuing, intensive development effort on a broad front at a level comparable to the 1960 rate, for the next 5 or 6 years, as now foreseen.

Reactor systems now under development in the civilian program can be divided into six general groups. Within these groups a number of variations are currently in differing stages of development. The following paragraphs describe the current status and type of work anticipated for each of these reactor groups:

1. *Light water-cooled reactors.*—Included in the light water-cooled group are the pressurized water, boiling water, and nuclear superheat types. There is a relatively high probability that light water-cooled reactors in the reasonably near future can achieve competitive power in the high fuel cost areas of the United States where large single units are practical. In addition, water reactors also offer a longer range potential of being competitive in many other areas of the United States.

Over the next 4 or 5 years, Commission supported research and development work on water reactors will be aimed primarily at solutions of the problems of nuclear superheat, increased fuel life, decreased fuel costs, simplified fabrication techniques, fuel management, simplified and less costly containment methods, and cheaper materials and methods of construction. A major effort will be made to develop techniques for economically utilizing plutonium as a fuel material in water reactors.

2. *Organic-cooled reactors.*—There is relatively high probability that organic-cooled reactors can achieve competitive power in high fuel cost areas of the United States by 1967 or 1968 and, in the longer range, over many other areas. Because of the success in operation of the organic moderated reactor experiment and in other research and development work already done, because of the relative simplicity of the system, and because of the direct applicability of much of the technology developed in water reactor programs, it is believed that this concept can achieve its early potential with less research, development, and plant construction than required for other reactor concepts.

Organic-cooled reactors operate at higher temperatures and lower pressures than water reactors, and have no major corrosion problems. These characteristics make for low capital cost plants. However, high costs for replacing decomposed coolant are an economic disadvantage. Organic coolants also have poor heat transfer characteristics and require fuel elements with extended surfaces and high conductivity cladding. Since a longer lived fuel must be developed, research and development work at present is primarily on aluminum-aluminum oxide claddings for uranium oxide and uranium alloy fuel materials. Research and development work also is directed toward lower organic makeup costs and improving organic fluid flow and heat transfer characteristics.

In the longer range, the research and development program will be directed toward utilizing plutonium recycle in organic reactors.

3. *Sodium-cooled reactors.*—Sodium-cooled reactors appear to have a high potential for achieving competitive power in large areas of the United States in the early 1970's.

Sodium has many attractive features as a reactor coolant. It is liquid at relatively low temperatures, has a very high boiling point, reasonably low neutron absorption cross section, and excellent heat transfer and heat transport qualities. These characteristics make possible very high steam cycle efficiencies. Because of the negligible pressure required for sodium systems very large sized (500 MWE and larger) reactors are practical.

Since liquid sodium is not in itself a moderator, systems which use this material as a coolant can operate over a wide neutron energy spectrum, depending upon the presence and characteristics of moderating material. In fast and possibly in epithermal systems, liquid sodium-cooled reactors are capable of breeding. Sodium-cooled reactor systems can also operate with uranium-plutonium fuel systems or with uranium 233-thorium systems. Sodium-cooled fast and thermal reactors are discussed separately below.

(*a*) *Sodium-cooled fast reactors.*—Most of the technical and economic advantages which are inherent in the use of sodium as a reactor coolant apply to these fast systems. They have an additional advantage in their ability to achieve high conversion ratios or to breed.

The research and development program for the fast, or epithermal, liquid metal cooled reactor system is long range in nature and is expected to yield significant results in the late sixties. In its initial stages, it will concentrate on the development of a satisfactory, long life, high burnup fuel material; on the utilization of plutonium and uranium 233 as fuels and of uranium and thorium as blanket materials; on the development of reliable and less expen-

sive sodium components; and on the development of efficient and rapid fuel recycle methods.

(*b*) *Sodium-cooled thermal reactors.*—Sodium-cooled thermal reactors have the potential of achieving economic power in high fuel cost areas of the United States. These reactors can be operated at high temperatures and low pressures. However, to obtain full benefit from these characteristics, a greatly improved fuel element must be developed: one capable of long life in the high temperature environment. For this reason it is unlikely that this potential could be achieved at an early date.

Since sodium-cooled fast reactors offer most of the advantages of the sodium-cooled thermal systems and in addition, offer the possibility of lower fuel costs through breeding, work on sodium-cooled thermal reactors will not be accelerated until operating results from the Hallam reactor, now under construction, can be evaluated. Research and development for sodium-cooled thermal systems will concentrate on uranium carbide fuel development and on major improvements in the design, efficiency, and performance of the sodium components. In carrying out this program, full consideration will be given to the points of similarity between thermal and fast sodium-cooled systems and the work will be directed in such a way as to achieve maximum benefit to both.

4. *Enriched gas-cooled reactors.*—Enriched, gas-cooled reactors have the potential of producing superheated steam of the quality currently in use in large central station powerplants with the resulting high efficiency. Since gas-cooled reactors can operate at low pressure, they can be built in very large sizes.

The Commission has parallel approaches to the gas-cooled reactors program, exemplified by the 22.3 MWE experimental gas-cooled reactor (EGCR) now under construction and the Philadelphia Electric Co.'s 28.5 MWE high temperature graphite reactor (HTGR). The HTGR will employ a core utilizing a graphite clad fuel consisting of fully enriched uranium carbide and thorium carbide dispersed in graphite. The EGCR is a reactor utilizing stainless steel clad, slightly enriched uranium dioxide fuel. In the case of both reactors, heat is removed from the fuel by the helium coolant and is transmitted to a heat exchanger where steam is formed to drive the turbine. The graphite clad system shows greater economic potential than the metal clad system, but presents more difficult development problems.

The present and immediately foreseeable research and development program is concerned primarily with the design and construction of the EGCR and HTGR. Their construction and operation will make possible a more comprehensive evaluation of the potential of the gas-cooled reactor system. The program also will include investigations of fuel and cladding materials suitable for high burnup at fuel surface temperatures of 1,700° F. and higher and of alternate coolants.

5. *Heavy water reactors.*—Heavy water moderated natural uranium fueled reactors have a number of unique advantages. For example, they eliminate dependence upon diffusion plants in the fuel cycle, they have high neutron economy, and they require relatively small inventories of uranium ore per unit of power produced. On the other hand these reactors are physically large, with consequent high capital costs. The reactivity lifetime of the natural uranium fuel is more limited than that of enriched uranium fuel.

Negotiations are currently underway with Canada on an expanded program for cooperation in the development of heavy water reactors.

The U.S. research and development program will be directed toward those problems which are critical to the evaluation of heavy water moderated systems. It will use to the fullest extent possible pertinent information being developed in other programs and in other countries. The critical problems are those associated with reactivity limitations on fuel lifetime (including fuel management techniques for extending these limits), minimizing loss of heavy water, and fabrication techniques for the components of either pressure-tube- or pressure-tank-type systems. One difficult design objective is to obtain high coolant temperature for high thermal efficiency while maintaining a cool moderator necessary for long fuel reactivity lifetime.

6. *Aqueous homogeneous reactors.*—The aqueous homogeneous reactor offers many advantages for production of power as it operates with a solution fuel, incorporates continuous fission product removal, and is largely self-regulating due to the large negative temperature coefficient. It further offers the possibility of breeding when operated on a uranium 233-thorium fuel cycle. Major technical problems are associated with the corrosive nature of the fuel, stability of the fuel solution under irradiation, the maintenance problem associated with

the radioactive primary loop, and the limited operating temperatures with the attendant low steam cycle efficiencies.

It is still too early to determine whether the simplicity of the fuel cycle and potential breeding will be more than offset by technical complexities and temperature limitations. Because of the unique advantages and the fact that this is the major program in civilian reactors which is exploring fluid fuels, research and development will be continued on the technical problems on a long-range basis.

As technology is developing rapidly, the Commission must remain alert to new reactor ideas as well as to ideas for major improvements in proven reactor types. However, a decision to proceed with the development of design alternates representing major technological advances depends upon an evaluation of the benefits expected to result. Such an evaluation is difficult even when considerable technical data on the alternate exists. The need for technical information may justify early construction of inexpensive reactor experiments which will provide answers to key problems of technical feasibility of advanced designs which otherwise look promising.

Some of the concepts currently being investigated include fused salt, fluidized bed, supercritical water, slurry fuel, gas-cooled pebble bed, and solid moderated steam cooled.

Engineering studies, research and development, and evaluation of the new reactor concepts will be continued to the point where a decision can be reached to either build a reactor experiment or to terminate the work. During the next few years it is probable that three to five of these concepts will have reached the point where the construction of a reactor experiment will be justified. Subsequent evaluation of the results from these experiments will probably justify the construction of several prototypes.

In addition to the specific work carried on under individual power reactor projects, there is an area of more broadly based development—the nuclear technology programs. These programs provide basic data on reactor systems and related problems, carry out engineering development of a general and fundamental nature, investigate the feasibility and potential of new methods for improving reactors, and provide tools, such as test and research reactors and remote handling devices, for use in reactor research and development.

Developments in this area should help to lower the cost of nuclear power generation through improvements affecting many types of reactors and through reductions in the overall cost of the reactor fuel cycle. Work is planned in the fields of fuels and materials, fuel reprocessing, waste disposal, reactor physics, components, and safety.

Research in physical sciences

Physical sciences work is discussed under the following headings: "Controlled Thermonuclear Research," "High Energy Physics," and "Other Physical Research." The first two programs were just starting 10 years ago; consequently, their growth curves have been sharply upward. At present, controlled thermonuclear research and high energy physics each account for about one-fourth of the physical research budget, with the remaining one-half supporting chemistry, metallurgy, mathematics, and low energy physics. Controlled thermonuclear research costs are expected to remain stable for the next few years. High-energy physics costs will continue their sharp climb, and other physical research costs will grow at a more gradual rate.

Controlled thermonuclear research

Costs for the controlled thermonuclear program are summarized below:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$0.1	1956	$6.7
1952	.2	1957	10.7
1953	.8	1958	18.4
1954	1.8	1959	27.0
1955	4.7	1960 (estimated)	36.5

As pointed out above, the work on fusion power has three successive goals:

1. To reach the ignition energy of ionized hydrogen isotopes—the point at which a self-sustaining fusion reaction occurs—with a time of confinement sufficient for proper study of the thermonuclear plasma;
2. To proceed toward a net power producer;
3. To produce economical thermonuclear power.

The theoretical value for the ignition energy of the deuterium-tritium reaction is about 4,600 electron volts. The value for the deuterium-deuterium reaction is about nine times higher. Restricting attention to the case of deuterium and tritium, a figure somewhat superior to that value—say 5,000 volts—is desired. In the fiscal years 1958 and 1959, the level of ion energy attained went up by a factor of 10, from 100 to 1,000 volts, or in a few cases, somewhat more. This statement excludes the approach pursued at Oak Ridge, in which ions are injected with a final energy of the order of 300,000 volts but where the density of the confined material is very low.

There is general confidence that the ignition energy can be attained, probably by a variety of methods. It is hoped that the ignition energy may be reached in a relatively short time, perhaps in 1 or 2 years. But such a hope has been entertained earlier, only to run into new technical difficulties after some of the more apparent ones had been overcome. Therefore, it is safer to say that the time for attainment of goal 1 may be 5 years.

When and if the ignition energy is reached, the emphasis would shift to engineering and chemical studies, such as intensive work on wall materials, shielding, and magnetic coil design, preceded by a thoroughgoing feasibility study that will overlap the first 5-year period.

No estimate can be made of the duration of an engineering phase leading to the first power producer. Experience in the fission reactor field suggests that this phase might last for 15 or 20 years. In any case, it is practically certain that it would extend beyond the 10-year projection considered in this report.

It is anticipated that the scale of effort in the first 5 years of the decade, or until the ignition energy is achieved, will be somewhat below the current level, unless any of the existing programs should meet with apparently insuperable obstacles, in which case the level might be reduced. Once the ignition energy is reached, work toward the second goal would involve a major step upward in financing, whose magnitude cannot be estimated at present.

High energy physics.—Costs for research and development in the rapidly expanding field of high-energy physics have grown in the last 10 years as follows:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$5.1	1956	$11.4
1952	5.6	1957	16.1
1953	7.8	1958	17.9
1954	7.3	1959	25.0
1955	7.8	1960 (estimated)	33.2

Large accelerators under construction at Argonne, Brookhaven, Harvard, and Princeton will be completed during the early 1960's. Their operation, plus the cost of experiments conducted by on-site and off-site researchers, will lead inevitably to a continuation of this upward trend. It will be the Commission's policy to improve existing machines and those under construction to provide better utilization of their capabilities, to the extent that such improvements lead to a capability for exploration of new and important areas of basic research. Such improvements will be costly, and the support of the expanded machines will be costly. Development of complex and expensive experimental apparatus will be required for observation and interpretation of experimental data. Studies of new machine designs will continue; studies so far indicate that probably the most desirable machine for early construction would be the linear accelerator proposed by Stanford University and currently being considered.

Other physical research.—Because of the very nature of basic research, it is difficult to outline a 10-year program in physical research, aside from the fields just discussed, where the work is tied to a relatively few devices. The projections are based largely on current and past experience; no plans can take into account the effect of new discoveries and their exploitation.

Cost of the physical research program, excluding controlled thermonuclear and high energy physics work, are summarized below for the last 10 years:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$24.5	1956	$36.0
1952	28.5	1957	37.7
1953	29.6	1958	45.9
1954	31.4	1959	51.9
1955	31.1	1960 (estimated)	64.1

Physics and mathematics.—Included here are the studies of low energy nuclear physics, extranuclear properties of matter, isotope separation, and mathematics and computer research.

The low energy nuclear physics studies, both experimental and theoretical, are basic to the Commission's programs in reactor and weapons development. An important part of this research is the nuclear cross sections measurements program for which a pool of separated, stable isotopes has been established at the Oak Ridge National Laboratory, and for which an expanded stable isotope production program has been initiated in order to provide further needed samples. This area of research is heavily dependent on the availability of such devices as high flux reactors, cyclotrons, and Van de Graaff generators. During the next few years, 3 new research reactors and a number of new low energy accelerators will be coming into operation under Commission sponsorship. As machine development progresses, new devices will be required to keep the work in step with scientific advances. Much of the theoretical research is directly connected with these low energy studies and the planning of useful experiments in this field is perhaps more dependent on theory than is the case in other fields.

The studies of extranuclear properties of matter which include optical spectroscopy, mass spectrometry, and low temperature phenomena, will continue with little expansion. This work does not require a large expenditure of funds and provides support for the Commission's broad technological interests.

Research on several methods of isotope separation has been underway for the past years with encouraging results. As the technical knowledge developed warrants large scale testing of a particular method, there will be a substantial increase in effort and funding in this area.

The growth of computer application within the Commission's programs has had its impact on computer and mathematics research. The high speed electronic computer has become an important tool of research and the numbers in use in basic studies will double or triple in the next few years. Research in applied mathematics will also increase to meet these requirements.

A new and growing problem is the effective handling of the vast amount of data produced by the new bubble chambers and similar detecting equipment. Next year alone the 72-inch liquid hydrogen bubble chamber at the Lawrence Radiation Laboratory in Berkeley will produce an estimated 2 million photographs to be analyzed. Work is beginning on methods for automating this analysis and thus increasing the research output per scientific man-year.

The direction and significance of the experimental program is closely related to its interplay with theoretical research. An intelligent use of research potential depends substantially on the strength of the theoretical staff. Consequently, it will be important to assure the effectiveness of the theoretical work, both by furnishing staff and by augmenting mathematical and computer services.

The physics research programs are continually reviewed and where facilities have become obsolescent they are phased out of operation. Operation of a synchrotron has terminated this past year and that of a linear accelerator will terminate next year.

The Commission supported effort in low-energy physics, mathematics, and computer research is expected to grow steadily during the next decade. The high degree of interest that attaches to high-energy physics at the moment, and the magnitude of the costs involved, must not be permitted to obscure the importance of these other phases of the program. It is equally important that the utilization of scientific resources to the fullest be continued in these other areas as in the more spectacular high-energy field.

Chemistry.—Increased effort is anticipated with respect to (*a*) the chemistry of the actinide elements (the elements following actinium in the periodic table), especially plutonium and the transplutonium elements; (*b*) nuclear chemistry, particularly those areas related to high energy accelerators and high flux reactors; (*c*) the chemistry and thermochemistry of high temperature materials; (*d*) corrosion chemistry; (*e*) analytic chemistry and hot laboratory techniques required for work with higher levels of radioactivity; and (*f*) radiation chemistry.

The synthesis of larger quantities of the very heaviest of the transplutonium elements in high flux reactors, and the synthesis of heretofore unknown isotopes beyond element 102 in heavy ion accelerators will open up new fields of chemistry and physics research. New problems in the separation, handling, and analysis of these highly active, generally spontaneously fissioning, and probably short-lived nuclides are anticipated. The spontaneous fissioning of such nuclides as californium 252 will enable these nuclides to serve as intense, portable sources

of neutrons. Also, the operation of additional high energy particle accelerators in the 1960's will open new fields for investigation in nuclear chemistry.

Examples of areas which will probably receive relatively less emphasis in the future are development of chemical methods for separation of the isotopes of specific elements and studies of the chemistry of uranium fuel processing by aqueous methods. Certain phases of research on rare earth separations and purifications will eventually be transferred to private industry. Steps have been taken for the U.S. Geological Survey, Department of the Interior, to support in fiscal year 1961 work previously supported by the Commission on geochemistry investigations of uranium. Responsibility for financing work in the preparation of labeled organic compounds, being conducted by the National Bureau of Standards, will probably be transferred to that agency.

Metallurgy and materials.—Fundamental studies in the field of metallurgy and materials are recognized as requiring an immediate expansion of effort. Materials research is of the utmost importance to the Commission's development programs, as well as to the Nation's effort in outer space research. Some of the facilities needed for this expanded work already are underway or planned, including the metallurgical facility being built at Argonne, the metals and ceramics facility at Oak Ridge, and the high flux research reactors referred to above. In planning additional facilities, careful consideration will be given to arrangements, both location and operation, which will enable them to contribute to the country's ability to train additional qualified personnel so critically short in this field at present. The Commission believes that the Federal Government must look forward to providing, through the Commission and other agencies, a number of facilities for advanced materials research which would increase our knowledge in this basic area.

In the early years of the decade, some effort previously concentrated on the basic metallurgy of uranium will be reduced to permit expanded work on plutonium. A similar reduction in plutonium work can be anticipated for some years later. Considering the history of uranium research, and the large voids in plutonium knowledge that remain to be filled, it is doubtful if a downward trend in plutonium work can be expected during the decade of the sixties, however.

As the approach of the science of materials becomes increasingly sophisticated and understanding of the simpler systems increases, attention will probably shift, for example, from fundamental radiation studies of elemental semiconductors and face-centered metals to compound semiconductors and body centered or hexagonal systems.

The current level of support under the radiation effects program appears about adequate, although some new low temperature facilities are needed. Increased effort in crystal structure research on noncubic lattices, heavy ion bombardment of surfaces, surface physics in general, high temperature and high pressure research, and high flux neutron radiation studies are anticipated. New areas of study are foreseen on metastable phases in solids, ultra high temperature research and extremely high flux radiation effects other than neutrons.

Biology and medicine

During the last 10 years, the trend of research and development costs in the field of biology and medicine has been—

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$20.0	1956	$27.8
1952	23.2	1957	30.8
1953	24.4	1958	33.7
1954	24.7	1959	40.2
1955	26.6	1960 (estimated)	47.1

The program as a whole will require increased support in the next decade. Expansion in work on radiation effects, genetics, environmental radiation, toxicological research, and plant sciences is anticipated; cancer research and radiation protection work are expected to be carried on at about the present level of effort. A detailed discussion of each of these fields follows:

Radiation effects.—Studies of the molecular and cellular effects of irradiation are basic to an understanding of radiation effects on man. In this field, much of the work on the alterations produced by radiation in isolated biochemicals

is either being curtailed or reoriented. Instead, the emphasis is now being placed on (1) physical-chemical studies to determine the actual mechanisms which lead to the inactivation of critical cellular components, and (2) biochemical studies of the radiation effects on the large, organized structures found in cells.

The potential hazards resulting from detonation of atomic devices, from reactor operations, from experimental handling of relatively large quantities of transuranic elements, and from the beneficial applications of atomic energy create an increasing need for data concerning effects on organs and organ systems resulting from continuous and intermittent low-level intake of fission products and reactor effluent radioisotopes.

The program on whole body irradiation effects has been a continuing one that progressively changes emphasis to meet demands for new information pertinent to Commission operations and problems. The emphasis has in past years shifted more toward the evaluation of long-term or chronic radiation hazards, and an expansion of program is underway to study the effects of very low doses. The Commission has extensive facilities for this program and, since its establishment, has provided the principal scientific knowledge required for the setting of radiation health standards. Since irradiation effects decrease with decreasing dose, the existing facilities must be further expanded to permit studies on the scale required and testing of theoretical concepts that have arisen.

Genetics.—The Commission's genetics program is the only federally supported genetics research program specifically directed toward the analysis and interpretation of the genetic hazards of radiation exposure. While much of the program is at a stable level, that portion concerned with the direct estimation of mutation rates in mammals needs to be expanded to exploit recent findings on the dose-rate dependence of mutation induction quantitative effects. Greater emphasis must also be placed on quantitative and genetic effects as being the best way to assess the increased mutation rate of a total poulation. Studies of radiation genetic effects and mechanisms must be continued. New programs are anticipated on the biochemical genetics of man, a type of investigation suited to the Commission's installations where a variety of scientific disciplines are closely integrated. The research programs in population and biometrical genetics will also be expanded. The major studies in the genetics program continue to serve as sources of data for the whole scientific community.

Environmental radiation.—The program on environmental radiation is one in which the Commission must expand its support in the future.

Radioactive contamination from nuclear weapons tests has created a strong interest throughout the world in more detailed information on the distribution and variation of natural and artificial radioactivity, on the actual range of radiation doses received by man from these sources, and on the effects of these doses on the human population as a whole and in specific localities. Because of the lack of clear evidence regarding the effects of low doses on the health of large populations, and because of recent changes in recommended occupational exposure limits, the distribution and effects of environmental radiation at levels formerly thought insignificant have become mandatory subjects of study.

Both for the Commission program and in cooperation with other agencies which will gradually be building up their own analytical facilities, it will be important that the unique talent and varied analytical facilities existing at Commission laboratories be more fully exploited. The physical and biological transport processes affecting the distribution of contaminants dispersed on a worldwide scale by high-energy sources, such as bombs or rocket propulsion systems, will require more intensive study. New projects along these lines should be initiated in some of the Commission laboratories.

On the other hand, the part of the program dealing with the atmospheric transport of contaminants from low-altitude, low-energy sources such as land-based powerplants and chemical processing facilities can continue at about the present level. However, during the next decade, attention must be shifted more toward the interactions of airborne contaminants with the earth's surface and its vegetative cover and to mechanisms by which different nuclides enter the food chain.

The terrestrial ecology, marine biology, and oceanography programs are still undergoing development, being of recent origin compared with other biological researches supported by the Commission. Continued development of the environmental aspects of these disciplines is anticipated to require 6 to 8 years before these long-term programs can be in effective productivity.

Radiation protection.—Studies on the means of combating radiation injury have been at a fairly steady level for several years. No major expansions are anticipated. As present studies on protection against acute effects reach completion, increased effort should be placed on combating long-term injury and ameliorating genetic damage. Any effort in this direction will require cooperative activity with the AEC laboratory programs in genetics and radiation toxicity.

The development of prophylactic and therapeutic procedures to combat the deleterious effects of radiation has been recognized as a responsibility of the Commission for many years. Although the number of workers accidentally exposed to severe doses of ionizing radiation has been small, the need for rational procedures of evaluation and therapy is, nevertheless, important.

The blood-forming cells of the bone marrow are particularly susceptible to damage by penetrating radiation, and destruction of these cells is the underlying cause of death following both acute and chronic overexposure. Commission-supported laboratories have investigated many therapeutic schemes during the past decade. Some of these continue to hold promise and will receive continued support. A number of drugs and natural products have been evaluated in Commission laboratories—for example, antibiotics, flavonoids, properdin, and various blood fractions. With the exception of the use of antibiotics, these investigations have not produced practical results. No increase in the present modest level of effort is planned unless new ideas are forthcoming.

A second method of treating acute radiation sickness may be the transplantation of new marrow in the patient to replace that destroyed by radiation.

The application of bone marrow treatment to larger animals and to man has been carried out principally by offsite contractors, because the technique seems to work best in the hands of surgeons. It is anticipated that the clinical evaluation of the bone marrow treatment will receive increased support in those Commission-supported laboratories affiliated with university medical schools.

Studies on burns and blast, having more direct relationship to the traumatic medical effects associated with actual warfare are being phased out or will be transferred to the appropriate group within the Department of Defense.

For reasons of practical necessity, much effort has been concerned with two very critical problems in radiobiology: (1) improving the physical measurements of the dose absorbed from both external radiation sources and internally deposited radioisotopes; and (2) quantitatively determining the biological changes (such as mutations, tumor formation, cataract formation, death, etc.) which appear hours, days, weeks, months, or even years later. However, the accumulating knowledge from these studies has demonstrated that, even in cases where there are good measurements of the dose, neither the extent of the resulting biological change nor the exact time of its onset can be precisely predicted. Thus, we need to reorient much of our effort toward utilizing physical measurements more efficiently in predicting the radiobiological damage from a given exposure. To do this requires the incorporation of many physical and biological factors into mathematical equations. Expansion of these efforts is planned for the immediate future.

Radiation detection instrumentation is keyed directly to both the biomedical research and the radiation safety control programs. Certain specific areas of instrumentation will be reduced or terminated by the natural completion of the effort. Of interest to note here is that the production engineering and fabrication of developed instrumentation has already been turned over to industry for support. The only exceptions to this are found where urgency requires the fabrication of a small number of instruments for the laboratories' immediate use.

The proportional level of support of radiation instrumentation as related to the biomedical research and radiation control programs is considered to be adequate. The opening of new areas of research, such as bioenergetics or low-level effects of radiation, will require intensified supporting instrumentation, but it is not anticipated that the proportionate cost should exceed the current ratio.

Moratoria on nuclear weapons testing, as a byproduct, cut off field experiments on the civil effects of nuclear weapons. Increased laboratory studies and theoretical work must, therefore, be substituted.

Toxicological research.—Inherently, atomic energy operations are not only faced with hazards from external radiation sources but with numerous other potentially hazardous agents which may be deposited within the body and must be regarded as either chemically toxic, radiotoxic, or both. Many of these hazards are associated with mining, milling, and concentrating operation in the

procurement of raw materials and ores and in the purification, fabrication, and reprocessing operations found in the manufacture of nuclear weapons and fuels. Research must continue to evaluate these hazards, to set tolerance limits, and to develop protective or corrective methods to control or neutralize these hazards.

The atomic energy industry can expand only as rapidly as the safe knowledge of handling certain materials permits. Since these materials and hazards are peculiar to the atomic energy industry, the Commission has both the responsibility and incentive for obtaining the necessary data.

Cancer research.—This program is expected to remain at about its present level as long as the laboratories continue to make useful contributions. The use of radiotherapeutic devices, including research involving high-energy sources, and the unique applications of radioisotopes in the program will continue.

Plant sciences.—The Commission should maintain its present level of activity in fostering the application of radiation techniques for the improvement of economic crops. This, at present, is largely a cooperative program involving many State agricultural experiment stations. Commission installations perform pilot studies and provide radiation facilities and radiobiological backup for the college and university scientists. The basic plant science program as related to radiation effects will be expanded, especially at the organism level, as recommended by an ad hoc committee of botanical scientists.

Peaceful nuclear explosives (Plowshare)

The use of nuclear explosives for peaceful purposes has been considered seriously for only a few years and the total amount of effort so far has been relatively small, but it is believed that the potentialities of this development may be great.

Costs since its inception have been:

Fiscal year:	*R. & D. costs (in millions)*
1958	$0.3
1959	2.4
1960 (estimated)	7.5

Nuclear explosions might affect water transportation by the digging of harbors and canals and greatly increase the usefulness of water resources by such means as the establishment of dams, increasing the permeability of underground formations, or by the diversion of water for irrigation purposes. Several approaches toward petroleum recovery have been considered and, while the difficulties seem great, the possible reward in the exploitation of tar sands, shales, and other presently unexploitable formations could have important consequences. The further possibilities of large-scale underground chemical reactions, the creation of underground heat supplies, and other related proposals indicate the significant benefits that might be anticipated.

It is not to be expected that all of these possibilities can be realized and, even less, that they will come to fruition before 1970. On the other hand, very substantial successes can be achieved in the coming decade.

The role of the Commission in this program should consist primarily in the development of new tools and approaches. New tools include the development of nuclear explosives which can be used for earth moving purposes without disseminating dangerous radioactivity, the development of nuclear explosives of lower cost, and the development of nuclear explosives designed for specialized peaceful applications. At present the estimated cost of a nuclear explosion competes favorably with other methods of blasting only for the larger yield. Another portion of the Commission effort might be the development of a nuclear explosive which would not reveal restricted data and would, therefore, facilitate usage.

The investigation of new uses of nuclear explosives are concerned with containment of nuclear explosions, distribution of the radioactivity produced and its effect on the surrounding environment, changes in the rock adjacent to the explosion, and, generally, effects of the intense heat and pressure produced by the explosion.

Unless barred or limited by international agreements or governmental decisions, research and development activity in the Plowshare program over the next decade is expected to increase somewhat as the problems become better defined.

Isotopes development

Isotopes development costs are summarized in the table below:

Fiscal year:	*R. & D. costs (in millions)*	Fiscal year—Continued	*R. & D. costs (in millions)*
1951	$0.9	1956	$0.3
1952	.5	1957	.3
1953	.5	1958	.2
1954	.3	1959	2.9
1955	.3	1960 (estimated)	3.7

The upward trend of effort in isotope development is expected to continue at least through 1961. Much of the work that will be needed to develop the technology on which private exploitation of isotope poentialities must be based is in the incipient stages.

International cooperation

Since the passage of the Atomic Energy Act of 1954, the United States has developed a broad program of cooperation and assistance with other countries. The essential components of this program have been development of agreements for cooperation in peaceful uses of atomic energy with other nations or groups of nations, the establishment and support of the International Atomic Energy Agency, the allocation of sizable quantities of uranium 235 for nuclear reactors abroad, the wide dissemination and exchange of information on peaceful applications, the support of training programs for foreign nationals in nuclear science and technology in U.S. universities and Commission laboratories, the provision of financial assistance to foreign countries for the acquisition of research materials and equipment, the development of measures designed to assist in the reduction of reactor operating costs and in estimating the costs of nuclear power, and the development of reactor concepts of potential application overseas.

These activities are considered to be an important and integral aspect of the Commission's operations. They have had a considerable impact on a number of Commission laboratories and promise to have an even greater impact over the next decade through expansion in foreign training programs at these installations, increase alien participation in laboratory projects, and a growth in specialized cooperative arrangements between the laboratories and foreign research institutions. In addition, as contemplated under the existing joint program with Euratom, it is likely that some programs will be undertaken or modified as a direct result of (*a*) cooperative technical programs entered into with other countries or (*b*) in the interest of developing reactor concepts that are particularly attractive overseas.

SECTION 4. SUMMARY AND CONCLUSIONS

Despite leveling off or decreases in some programs and completion or termination of specific projects, present indications are that the volume of research and development work incident to discharge of the Commission's statutory responsibility will increase during the next 10 years. The slope of the curve is expected to be less sharply upward than it has been in the decade just closed, during which many of today's large programs, both military and peaceful, were inaugurated and built to effective strength. Barring unforeseen program changes, this trend should be at a rate related to the growth of the national economy and the overall scientific potential. Much of the projected increase is required by program increases and additions already approved. To carry out these program changes and to remedy existing deficiencies, research and development facilities estimated to cost $700 million are under construction or authorized.[11]

The relationship between program increases and new facilities is not expected to be linear. In the years 1951–59 the following relationship prevailed between operating costs, completed facilities, and scientific and engineering employment at 16 major Commission laboratories (excluding CANEL and Evendale because of their non-Commission facilities, and the Cambridge and Princeton-

[11] A detailed list of research and development facilities under construction or authorized is contained in vol. II.

Pennsylvania accelerators because these facilities were not completed or in operation):

	1951	1959	Factor of increase
Operating cost (millions)	$146.8	$469.2	3.2
Scientists and engineers	4,207	10,144	2.4
Completed facilities (millions)	$231.4	$901.6	3.9

By and large, the basic complement of laboratory space, office buildings, and service facilities has been provided at the Commission laboratories. The Commission plans an orderly replacement of temporary structures which house permanent laboratory activities. While the major portion of existing research and development plant consists of office, laboratory, and service facilities, the major portion of facilities underway or authorized is made up of large experimental plants and devices—accelerators and reactors. These special facilities help to round out the capability of the laboratories and to make them better able to serve the needs of the Nation. Their operation will call for more operating costs and more manpower. However, the increases are not expected to be in direct proportion to the investment, since the manpower per dollar of investment in accelerators and reactors is significantly lower than it is in laboratory and office space.

The Commission's laboratories have acquired excellent facilities and, more important, highly skilled, well-rounded, and dedicated staffs. Their outstanding reputations throughout the world have been won by their productivity and their contributions in all of the fields of research and development within the Commission's areas of responsibility. With some specific exceptions, the facilities and the staffing of the laboratories appear to be equal in scope to the responsibilities that lie ahead for them. They are mature institutions, and incremental growth will be permitted only where necessary. Proposed expansions will be matters for individual consideration and evaluation. It is the judgment of the Commission that growth of the large multiprogram laboratories beyond the 4,000 to 5,000 level may well lead to cumbersome administration and, therefore, reduced effectiveness. The Commission, as a matter of policy, will seek to make room for new projects and undertakings in the laboratories by removing from the laboratories work which has been brought to the point where it can be carried on by others. It will, of course, always be necessary to assure that the laboratories' complement of essential tools, in terms of facilities and apparatus, is constantly kept in pace with new developments and new needs.

The role to be played by the laboratories in the future will continue to demand the highest level of scientific and engineering competence. The Commission will insist on the maintenance of such standards throughout its laboratories.

The increasing capability of industry and the universities, built in part on the work of the laboratories, makes it possible for the Commission to turn to industry and to the universities to an increasing extent as the program expands.

The Commission intends that the laboratories will remain paramount in pioneering work as the inventors and developers of new concepts and as the talented source of varied capabilities for tackling complex and unusual assignments. But increased responsibility will continue to be placed on industrial organizations to perform Commission-supported development, as the nuclear energy field progresses toward commercial application and as private organizations acquire capability in facilities and personnel. It is Commission policy to promote the participation of industry in the nuclear field on an increasing scale and to transfer to industry, as industry indicates its capability to perform, operations or functions now being performed in Government facilities. This policy will increase the ability of the laboratories better to discharge their own primary responsibilities and constantly to raise the quality of their own performance. In the fields of engineering and process improvement, simplification and cost cutting, and design for ease of maintenance and reliability of operation, where much remains to be done in order to achieve the goal of competitive power, industry, with both Federal and private financing, will play the major role, complementing the advanced work of the laboratories and applying the laboratories' research findings.

The support of a relatively greater increase in basic physical research and in biomedical research in the universities than at the laboratories is a continuation of the trend that has characterized the research programs in the physical sciences and, to a lesser degree, in the life sciences, throughout the past decade. Research at the universities yields as a byproduct the training of additional scientists—essential to staff the growing demands of research and development institutions throughout the economy and to maintain the United States in the forefront of scientific and technical affairs.

For the most part, Commission program requirements will keep the laboratories fully occupied during the decade of the 1960's. Nonetheless, the Commission recognizes that the strong capabilities of the laboratories are not the exclusive resources of the atomic energy field; they are held in trust for the Nation as a whole. Urgent work for other Federal agencies on matters of national concern will be accommodated in the laboratories when their skills are needed. There is no intention of making the laboratories into "job shops," but the laboratories and the Commission will continue to recognize national needs that call for out-of-the-ordinary arrangements, effort, and ability.

It is the intent of the Commission to assure that those laboratories essential to weapons research and development, the Los Alamos Scientific Laboratory, the Lawrence Radiation Laboratory at Livermore, and the Sandia Laboratory, be maintained as strong and vigorous institutions. Should there be some decrease in weapon research and development needs, consideration will be given to expanding these laboratories' nonweapon functions as the national interest requires. As far as practical such expansion will be in fields requiring talents comparable with those needed for weapons development.

The anticipated decline in production plant support needs at the Hanford and Savannah River Laboratories should free some facilities and talent for other work. Within Commission programs, such assignments are most likely to be in the nuclear technology field. As new tasks need to be undertaken, the capabilities of these laboratories will be carefully assessed, particularly if such assignments would otherwise call for expanding Government facilities elsewhere, or expanding the personnel of another Commission laboratory. But there is no intention to assign them tasks that can more appropriately be performed in private facilities, or to transfer going activities from other laboratories; "make work" tasks will not be resorted to as a means of maintaining the vitality of these institutions.

The opportunities for mutual enrichment of the research and training activities of the laboratories and the universities will continue to be more fully utilized during the decade. All of the factors linking the laboratories and the universities—organization, personnel, related research projects, common use of Commission-owned facilities—will be encouraged and strengthened. The laboratories' present complement of outstanding facilities and equipment will be maintained in front rank position by the acquisition of improved facilities as they are developed and as the needs of the program require. Progress has been made in recent years in arrangements for the utilization of these facilities by universities, both in the conduct of research programs and in affording opportunities to graduate students to do advanced work at the laboratories. Such arrangements have required modification of the normal practices of both the laboratories and the universities.

Enough experience has been gained, however, to demonstrate that such arrangements can succeed. They offer a fruitful area in which the laboratories can contribute to the very large demands that will be placed on the universities as a whole by the anticipated expansion of graduate student bodies in the years ahead. In a number of specialized fields there are relatively few universities in the country that can offer first rank facilities and broad graduate student instruction. The need for highly trained technical personnel will require that more institutions become so fitted. By appropriate arrangements the laboratories can add strength to those universities which are not fully prepared to meet the demands for advanced training in specific fields. As research becomes more complex and larger and more expensive facilities are required, highly specialized postdoctoral training becomes more important. While the universities will continue to handle both graduate and postgraduate levels with emphasis on graduate students, the Commission supported facilities will make greater contributions at the postdoctoral level.

Large accelerators and other unusual and expensive research tools, whether provided on university campuses or on Commission-owned sites, are intended

to serve qualified researchers from other institutions as well as those on the staff of the operating institution. The Commission will insist that these opportunities for broad use of its facilities in the interest of science be maintained.

The Commission and the laboratory managements will continue to examine their programs during the decade to identify areas of work offering the most promise for substantial progress, as well as those in which Commission support can be reduced or terminated. As developments reach the point at which the profit potential warrants, and industry assumes further development costs, the Commission will cease its support. In cases where the activities fall within the sphere of responsibility of other Federal agencies, the Commission will seek to develop arrangements for appropriate transfer of responsibility.

PART II. THE INDIVIDUAL LABORATORIES IN THE NEXT DECADE

INTRODUCTORY NOTE

The limitations on the validity of detailed projections for each of the laboratories are even greater than for the gross projections for major program segments in section 3. The plans that follow are only current judgments; and they become less firm the further they are projected from the present.

Frequent repetition of qualifying phrases has been minimized, but the fact that predictions about rates of growth, degrees of emphasis, initiation of new studies, and completion of current work are not commitments and must be subject to change is implicit throughout.

NOTES ON TABLES AND CHARTS

Equipment costs are excluded from research and development figures throughout the tables and charts. Movable as well as installed equipment is included in the completed plant and equipment data.

The personnel data for scientific and engineering employees are a better guide to relative levels of effort than are the total employee figures. Variations in the extent to which the laboratories are self-sustaining limit the comparability of total employee figures. For example, the Zia Co. furnishes various services, such as maintenance, to the Los Alamos Scientific Laboratory, while similar service functions at Argonne National Laboratory are handled by laboratory employees.

The "trend" tables and charts cover the 10 years from 1951 through 1960, except for those laboratories at which Commission work started subsequent to 1951, in which cases the data cover the work from its inception.

SECTION 5. MULTIPROGRAM LABORATORIES

Argonne National Laboratory

Argonne National Laboratory is the direct successor of the wartime Metallurgical Laboratory of the Manhattan Engineering District. The primary objectives of that Laboratory were to demonstrate the feasibility of a self-sustaining nuclear chain reaction, to develop the relevant technology to the point where nuclear reactors for the production of plutonium could be constructed, and to develop a process for the separation and isolation of plutonium. A very important ancillary responsibility was to develop information concerning the hazards involved in the use of radiation and radioactivity. To attain these major objectives within the time schedule, it was necessary to carry out, essentially simultaneously, engineering design and development, and applied research in the fields of physics, chemistry, metallurgy, biology, and medicine.

On July 1, 1946, Argonne was established as a permanent laboratory and the University of Chicago was selected as the operating contractor. As originally conceived the Laboratory's primary responsibility was that of basic research in the many areas of science pertinent to the long-range development of atomic energy. However, on January 1, 1948, the Commission assigned the Laboratory major responsibilities in the field of reactor development in addition to the research activities in which it was already engaged. This twofold responsibility of basic research on the one hand and applied research and development on the other has continued to the present.

Since the early fifties the work of the Laboratory has been almost equally divided (in staff man-years) between basic research and the applied and developmental work.

The major effort in development work since 1948 has been on water-moderated reactors (physics design and initial development work for the prototype of the *Nautilus* reactor (STR), the physics design of the Savannah River reactors, the heavy water research reactors at Argonne (CP–3 and CP–5), the series of boiling reactors experiment in Idaho called BORAX, the Experimental Boiling Water Reactor (EBWR), and the Argonne Low-Power Reactor (SL–1)), on fast reactors for power and breeding (experimental breeder reactors—EBR I and II), on the development of chemical processes for irradiated fuel, and on the development and experimental fabrication of fuel elements.

The Laboratory's physical research program was initially in the following broad areas of research: (1) Low energy neutron physics; (2) nuclear properties of the many new isotopes discovered during the metallurgical project or made available as a result of the project; (3) chemical and physical properties of elements either newly discovered or available in significant quantity and purity for the first time; (4) effects of radiation on solids, liquids, and gases; and (5) application of the special techniques developed during the metallurgical project to physical research in other areas. From this has grown the present extensive program of research in physical sciences which involves a wide variety of investigations in the fields of physics, chemistry, and metallurgy.

The present physics research is primarily in the field of low energy nuclear investigations; in preparation for utilizing the Zero Gradient Synchrotron (ZGS), a multibillion electron volt accelerator now under construction, increased emphasis is being placed on problems in high energy physics. The current basic chemistry program gives major emphasis to the inorganic and physical chemistry of the heavy elements, to nuclear chemistry and radiation chemistry. The program in physical metallurgy emphasizes the study of the properties of uranium, plutonium, and thorium with growing emphasis on plutonium. Although this work is basic in nature, much of it is concerned with problems that must be solved before plutonium can become a practical fuel for power reactors. High temperature research and solid state research are carried out at present on a relatively small scale.

Work in the life sciences is directed toward achieving an understanding of the action of radiation on living systems, with emphasis on the effects of neutron radiation. Studies of the effects of external and internal radiations are carried out on animals and, where appropriate, on humans who have been exposed to particular environmental conditions or what bear significant body burdens of radioactivity.

The laboratory's International School of Nuclear Science and Engineering, established as a part of the atoms-for-peace program, has given training to some 400 scientists and engineers from other countries who are now taking prominent parts in the development of atomic energy in their own countries all over the world.

The growing activities involving joint Argonne-university relationships are facilitated by Associated Midwest Universities, Inc., a recently organized nonprofit group of universities. Although the schools making up Associated Midwest Universities are located in the Mississippi Valley States, opportunities for participation in the Argonne program by university researchers are not limited geographically.

Argonne occupies a tract of 3,700 acres about 25 miles from Chicago, as well as two sites at the National Reactor Testing Station in Idaho. Among the many special facilities of the laboratory are the CP–5 research reactor, the experimental boiling water reactor, the Argonaut training reactor, exponential and critical assemblies, hot laboratories and many other facilities for handling radioactive materials, a new facility for developing fabrication techniques for plutonium, many specialized engineering test facilities, a 60-inch cyclotron, Van de Graaf generators, mass and optical spectrographs, several gamma irradiation facilities, counting equipment for all levels of radioactivity, and facilities for animal experiments. The construction of the Zero Gradient Synchrotron began in June 1959. At the National Reactor Testing Station the laboratory operates the experimental breeder reactor I, the transient reactor test facility (TREAT), the fast source reactor, and fast critical experiment facility (ZPR III) and is constructing a prototype size fast breeder (EBR II). The tables and charts on the following pages give a summary of dollar and manpower levels of the laboratory's operations for the last 10 years, and a detailed tabulation of the current budget.

Future plans

Current planning for Argonne National Laboratory contemplates moderate expansion of the staff to implement effectively projects already assigned to the laboratory. However, it is anticipated that during the period under consideration, as in the past, there will be significant changes in program emphasis.

Physical research.—The most readily foreseeable change in basic research will occur in high energy physics. With the construction of the zero gradient synchrotron, the laboratory will be in a position to carry on one of the Nation's major programs in this field. This facility, however, is not intended to serve as a piece of experimental apparatus for the staff of the laboratory alone; it is intended to be a device available to qualified high energy physicists of the Nation or of the free world. Therefore, the laboratory management and the Commission intend to limit the staff expansion at Argonne in the high energy physics field to the number required to assure the most effective use of the machine. It is planned that about one-half of the available time on the machine will be used by visitors to the laboratory. These visitors are expected to be faculty members and graduate students from universities and other research institutions.

In the low energy physics program, the present level of effort is not expected to change markedly, although there will be significant changes in the direction of some of the work, particularly as facilities presently authorized or contemplated become available. The principal new facility already authorized is the 10 Mev. tandem Van de Graaff.

In the chemistry program increasing attention will be devoted to the chemistry and nuclear chemistry of the transplutonium elements, particularly in the use of the new Chemistry Hot Laboratory. The chemistry of plutonium will also receive continuing attention. Effort will be initiated in high energy chemistry in connection with the ZGS. The radiation chemistry program will continue at approximately its present level as will the general nuclear chemistry activities. Wherever it would be effective, the proposed changes will be accomplished by the transfer of staff from less urgent activities.

Because of the limitations on technology now imposed by knowledge of the behavior of materials under the new conditions met with in reactor operations, both the chemistry and metallurgy programs will devote increased attention to studies of the behavior of materials at high temperatures and to corrosion phenomena. Wherever possible the expansions in these fields will also be accomplished by the transfer of effort from other areas.

Expansion is anticipated in solid state studies, in ceramics research, and in theoretical and experimental investigations in the basic aspects of metallurgy.

There will be only minimal effort of plasma physics, and no activity in large scale controlled thermonuclear research is envisaged.

With the growing need to develop the use of plutonium as a reactor fuel, the basic properties of plutonium as a metal and as an alloy material must be intensively investigated. The metallurgy program is already in process of shifting its emphasis from uranium to plutonium. Although the basic properties of uranium will continue to receive some attention, it now appears that as the decade advances, more and more of the Metallurgy Division's research effort will be concerned with plutonium.

Argonne National Laboratory, Lemont, Ill.: 10-year trend—Costs, staff, and facilities

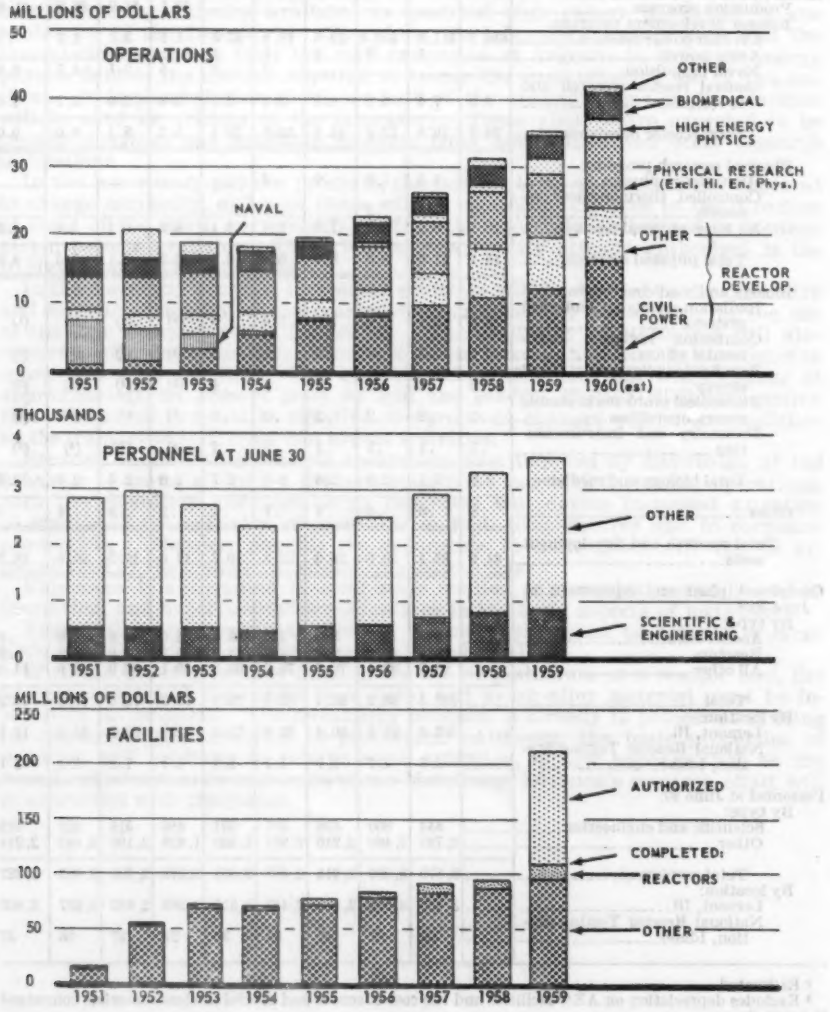
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	------	------	------	------	------	------	$0.1	$1.9	$3.9	$1.8
Reactor development program:										
Civilian power reactors	$16.1	$11.8	$10.6	$9.6	$8.4	$7.5	5.1	3.1	1.2	.8
Army power	------	.4	.4	.3	.1	.1	------	------	------	------
Naval propulsion	------	------	------	------	.2	.2	.5	2.1	4.7	6.6
General reactor research and development	7.9	7.4	6.9	4.5	3.3	2.7	2.9	2.9	2.1	1.6
Total reactor development	24.0	19.6	17.9	14.4	12.0	10.5	8.5	8.1	8.0	9.0
Physical research program:										
High energy physics	2.9	2.3	1.0	.9	.4	------	------	------	------	------
Controlled thermonuclear research	.1	.1	.2	------	------	------	------	------	------	------
All other physical research	10.1	9.2	8.0	7.5	6.4	6.1	6.2	6.1	5.5	4.8
Total physical research	13.1	11.6	9.2	8.4	6.8	6.1	6.2	6.1	5.5	4.8
Biology and medicine program:										
Radiation effects on biological systems	2.5	2.1	1.6	1.5	1.2	1.3	(3)	(3)	(3)	(3)
Combating radiation detrimental effects	.6	.5	.6	.6	.8	.5	(3)	(3)	(3)	(3)
Beneficial applications of atomic energy	.5	.4	.4	.4	.4	.4	(3)	(3)	(3)	(3)
Biomedical problems in atomic energy operations	.2	.2	.2	.2	.2	.3	(3)	(3)	(3)	(3)
Dosimetry and instrumentation	.1	.1	.1	.1	.2	.2	(3)	(3)	(3)	(3)
Total biology and medicine	3.9	3.3	2.9	2.8	2.8	2.7	2.6	2.4	2.8	2.6
Other	.9	.6	.8	.4	.7	.4	.2	.2	.4	.5
Total research and development costs	41.9	35.1	30.8	26.0	22.3	19.7	17.6	18.7	20.6	18.7
Completed plant and equipment at June 30:[4]										
By type:										
Accelerators	------	3.3	3.2	3.0	3.0	3.0	3.0	2.9	2.9	.4
Reactors	------	11.5	9.6	9.6	4.2	4.1	4.1	.8	.8	.8
All other	------	92.7	83.4	79.5	76.7	69.0	66.1	69.9	51.6	14.0
Total	------	107.5	96.2	92.1	83.9	76.1	73.2	73.6	55.3	15.2
By location:										
Lemont, Ill	------	103.6	94.5	90.4	82.8	75.0	72.1	72.5	54.2	14.1
National Reactor Testing Station, Idaho	------	3.9	1.7	1.7	1.1	1.1	1.1	1.1	1.1	1.1
Personnel at June 30:										
By type:										
Scientific and engineering	------	844	800	698	577	531	488	519	521	513
Other	------	2,735	2,499	2,216	1,911	1,820	1,828	2,190	2,462	2,314
Total employees	------	3,579	3,299	2,914	2,488	2,351	2,316	2,709	2,983	2,827
By location:										
Lemont, Ill	------	3,480	3,248	2,872	2,453	2,315	2,289	2,682	2,957	2,800
National Reactor Testing Station, Idaho	------	99	51	42	35	36	27	27	26	27

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available.
[4] Plant projects authorized but not completed at June 30, 1959, total $103.5 million. Of this amount $71.7 million is to be built at the Lemont site and $31.8 million will be at the NRTS.

ARGONNE NATIONAL LABORATORY

RESEARCH AND DEVELOPMENT



Argonne National Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$30,795	$35,050	$41,878
Reactor development, total	17,918	19,599	24,005
Civilian power reactors, total	10,644	11,784	16,153
Boiling water reactor, total	3,495	3,721	4,700
Research and development	2,585	3,121	2,900
Fuel fabrication		11	1,000
Test operations	610	575	800
Reactor experiment fabrication	299	14	
Fast power breeder reactor, total	6,627	7,594	11,300
Research and development	6,007	6,723	7,600
Fuel fabrication	388	619	2,600
Test operations	185	252	1,100
Reactor experiment fabrication	47		
Liquid metal fuel reactor: Research and development	163	94	
Studies and evaluation		182	153
Assistance under power demonstration program PRDC	360	193	
Nuclear technology and general support, total	6,881	7,451	7,852
Engineering physics and advanced reactor development	1,482	1,455	2,005
Reactor fuels and materials development	962	894	965
Reactor components development	934	1,147	1,290
Separations development, total	1,552	1,408	1,695
Aqueous chemistry process development	229	315	427
Volatility processing development	836	607	635
Closed cycle process development	487	486	633
Reactor safety, total	1,765	2,372	1,670
Thermal reactor safety	305	503	570
Fast reactor safety	1,460	1,869	1,100
Radioactive residues process and control: Treatment development	186	175	227
Army power reactors, total	393	364	
Stationary low power, total	393	364	
Research and development	284	225	
Fuel fabrication	101	17	
Test operations	8	122	
Physical research program, total	9,203	11,568	13,120
Physics research, total	3,752	5,234	5,997
High energy physics	994	2,313	2,865
Nuclear structure and neutron physics	2,172	2,326	2,512
Extra nuclear properties of matter	340	336	365
Physical methods of isotope separations			
Computer research and development	245	259	255
Chemistry research, total	4,336	5,042	4,897
Process chemistry	732	935	1,012
Chemical properties and reactions	3,084	3,628	3,420
Special projects	520	480	465
Metallurgy and materials research, total	946	1,184	2,166
Production, treatment, and properties of material	652	807	963
Alloy theory and the nature of solids	182	203	1,009
Effects of irradiations on materials	112	174	194
Controlled thermonuclear research: General research and development	169	108	60

Argonne National Laboratory: Current budget and recent costs by categories of work—Continued

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Biology and medicine program, total	$2,918	$3,257	$3,900
Radiation effects on biological systems, total	1,581	2,055	2,547
Medical research	82	41	128
Biological research	1,463	2,014	2,419
Biophysics research	36		
Combating radiation detrimental effects, total	557	496	599
Medical research	312	339	415
Biological research	245	157	184
Beneficial applications of atomic energy, total	431	388	474
Cancer research	64	103	111
Biological research	367	285	363
Biomedical problems in atomic energy operations, total	226	187	170
Medical research	5		
Biological research	67		
Biophysical research	154	187	170
Dosimetry and instrumentation, total	123	131	110
Dosimetry	92	131	110
Instrumentation	31		
Training, education, and information program, total	756	626	853
Operation of schools	583	510	728
Assistance to schools	93	79	75
International conferences, exhibits, studies, and other assistance	80	27	
Publications and libraries		10	
Other training, education, and information			50

Reactor development.—The reactor development work of the Laboratory over the last decade has occupied approximately half of the Laboratory's professional, scientific, and engineering staff. In the decade ahead this 50–50 distribution will no longer obtain. The marked increase in the basic research work arising from the high energy physics program and the lessening requirement upon the Laboratory for "heavy hardware" projects as industry increases its competence in the nuclear power field, both tend to decrease the relative magnitude of the reactor work. Within the Laboratory's reactor development program itself, the emphasis will shift from large projects aimed at early achievement of competitive economic power from nuclear fuels, to longer range and more radical applications of nuclear reactors. This change will involve increased emphasis within the Laboratory on the general engineering research which is essential to furnish the foundations of the new technologies which will be required.

The Laboratory's major responsibility in the boiling water reactor field will be gradually phased out as the pioneering types of questions on the boiling cycle are answered and as industry takes over the problems of engineering development and process refinement which will remain. The fast breeder reactor as a source of power and of fissionable material will continue to occupy a significant part of the laboratory's development effort throughout the decade.

As the responsibilities for central station power decrease, the Laboratory's investigations on new and advanced nuclear reactor concepts will be increased. Such investigations are expected to involve simple reactor experiments of the BORAX type, intended to determine the technical feasibility of advanced concepts and the desirability of carrying out further, more elaborate engineering development. Where the basic technologies are essentially new and industry is not prepared to take over further development, reactor experiments of the EBWR scale may be carried out to test the engineering feasibility of the new concept. Only in exceptional cases, not now foreseen, will the Laboratory be expected to carry out "prototype" reactor projects.

New concepts now under consideration include the boiling slurry reactor, fluidized bed or dust fuel reactors, boiling liquid metal cooled reactors, and pulsed reactors.

Fuel cycle work on both the boiling water reactor and the fast breeder reactor are expected to continue throughout the period.

Work will be expanded in some fields of general reactor technology to supply the information needed in connection with investigation of new reactor concepts. In particular, heat engineering studies on heat transfer and fluid dynamics of liquid metal coolants, both single phase and two phase, will be increased. Metallurgical investigations of high temperature fuel materials and materials of reactor construction will both receive increased attention. Problems of instrumentation at very high temperatures will also require increased effort.

It is probable that there will be a modest increase in the fuel reprocessing development program. Work on the fluidized bed technique for fuel reprocessing will continue through the next few years, but is expected to drop out in the latter half of the decade. Utilization of fluorination techniques for the processing of refractory fuels will also continue. It is anticipated that work on pyrometallurgical processing will increase in importance during the coming 10 years.

Biology and medicine.—As knowledge of the acute effects of radiation has increased, greater emphasis has been placed on the chronic effects of low-level exposure to radiations, in anticipation of the increasingly important problems that will result from widespread use of nuclear reactions for power production. Consequently, a major program expansion on long-term biological effects of low-dose radiation is underway. Because of the low doses and dose rates involved, such studies require a considerable expansion of experimental animal facilities. In addition to studying the effects of fission neutrons, high-energy gamma radiation, and strontium 90 deposition, the program will undertake to evaluate the effects of a variety of mixed fission products, both short and long lived. Emphasis will be on the life shortening and carcinogenic effects.

In addition to the large-scale laboratory animal studies, a detailed epidemiological study on human populations is rapidly gaining impetus. Between 500,000 and 700,000 persons in Illinois are routinely drinking well water that contains above-average levels of radium; some waters contain levels near the maximum permissible content. Body radium burdens will be measured and correlated with estimates of the incidence of bone pathology and bone tumor mortality. These studies are integrated with the continuing followup of radium dial painters and other persons known to be carrying significant body burdens of radium.

Certain projects in the plant sciences concerned with radioisotope labeling of compounds involved in biosynthesis will be brought to completion.

Studies of the biochemical factors which account for difference in the radio sensitivities of individual cells within a population will be expanded as they are required by the long-range neutron and gamma ray toxicity project. A comprehensive program on the biological effects of fission neutrons at dose rates varying from about .0001 to 10,000 rad per hour will be initiated upon the completion of a special biological research facility in 1960.

University relations.—Throughout its programs, the Laboratory will give increased emphasis to opportunities for research and training interchanges with universities.

Brookhaven National Laboratory

Brookhaven National Laboratory was established in 1946 in recognition of the need for large and expensive equipment and concentrations of scientific manpower in conducting nuclear research. The Laboratory is operated by Associated Universities, Inc., a nonprofit corporation formed for the purpose under the sponsorship of nine leading northeastern universities. The Brookhaven program is characterized by emphasis on basic research and by large scale participation of scientists and engineers from other institutions.

The Laboratory occupies the former Camp Upton in central Long Island. Some 150 Army buildings are still in use, although some are permanent, a large number are of temporary barracks-type construction and are gradually being replaced. New construction to date includes centers containing the major technical facilities, part of the biology laboratory, a new medical center, and a few small, special purpose buildings. Under design are a physics laboratory and the first phase of a nuclear engineering building.

The research is centered around, though not confined to, the use of several large machines and other special facilities, including: a large research reactor; a 3 billion electron volt proton synchrotron (this "Cosmotron," completed in

1952, was the first accelerator to deliver particles with energies above 1 billion volts); a 60-inch cyclotron and several smaller accelerators; a hot chemistry laboratory; and several high level radiation facilities including a gamma field and a gamma greenhouse for the irradiation of growing plants. The new medical center incorporates a small research hospital and its own nuclear reactor especially designed for clinical neutron irradiations and other special purposes. A 30 billion electron volt proton synchrotron, to be completed in 1960, will keep the laboratory in the forefront of research in high energy physics. A high flux research reactor now under design will provide much higher intensity external neutron beams for use in many facets of the program.

The scientific program covers a wide range of subjects in the physical and biological sciences and in engineering. It can be broadly described under five major headings.

1. Fundamental studies of atomic nuclei, the particles which constitute them, and the forces involved in their structure. This work, which is the Laboratory's largest single effort, uses all the major machines. Especially significant results have been achieved in high-energy-particle physics, in neutron physics and in certain important aspects of nuclear structure.

2. The physical, chemical, and biological effects of nuclear particles and radiations. Such effects are utilized to study physical and chemical structures and the more complex properties of living systems and the changes which they undergo in their life and reproductive cycles. Of direct practical interest are deleterious effects of neutrons and other radiation upon biological systems and upon structural and other materials involved, for example, in reactor construction. Of equal importance are the potentially beneficial effects in the treatment of disease, in inducing useful genetic changes in plants or animals, and in assisting manufacturing processes. Special emphasis is placed on the use of neutrons in much of this work.

3. The use of nuclear tools, such as radioisotopes and neutrons, to study physical, chemical, and biological systems in an undisturbed state. In addition to applications of isotopic tracers in studying physical, chemical, and biological systems and processes, this category includes the use of neutrons and other particles as probes to study the microscopic details of physical and chemical structures by observing their penetration and reflection.

4. Research and development, not necessarily itself involving nuclear phenomena, directed at the problems of atomic energy development. In its more basic aspects this category includes the chemistry and metallurgy of substances of special interest and the neutron scattering and absorbing properties of materials used in reactors and atomic weapons. In its immediate application it includes the development of reactor components such as fuels, structures, and shields; of components and processes for the chemical processing and useful recovery of reactor products; and theoretical and experimental studies in the field of reactor physics.

5. The development of specific devices. This includes both the design and the construction of special research tools such as accelerators, reactors, and other technical equipment, and the development of radiation sources and other devices utilizing atomic energy.

The scientific staff presently includes slightly more than 300 scientists and engineers on the Brookhaven staff proper, approximately 70 postdoctoral research associates, and some 300 visitors from other institutions who average somewhat more than one-third of their time at the Laboratory. About 60 foreign nationals are in residence on temporary appointments as research associates or visiting scientists.

Trends of costs, budget, facilities, and staff are shown in the following pages.

Future plans

Measured in terms of scientific and technical effort, considerably more than half of the work at Brookhaven is in the physical sciences; the remainder is about equally divided between nuclear technology and life sciences research. Over the coming 10 years, a substantial expansion of the total Brookhaven effort is anticipated, with much of this increase occurring during the first 5 years.

Physical sciences.—Of the growth in basic research in the physical sciences, nearly half is expected to be in the high-energy physics program as a result of the new 30-Bev. alternating gradient proton synchrotron, scheduled for initial test operations in 1960, and of improved research facilities at the cosmotron. Additional emphasis also is envisaged with respect to the solid state physics and metallurgy programs and in radiation chemistry.

The Brookhaven scientific staffs in high-energy physics, nuclear structure, and neutron physics are expected to increase significantly. The nuclear structure and neutron physics program will move into new, relatively unexplored fields through the acquisition of the high flux beam research reactor and, possibly, a high-intensity, intermediate-energy cyclotron.

Brookhaven National Laboratory, Upton, Long Island, N.Y.: 10-year trend—Costs, staff, and facilities

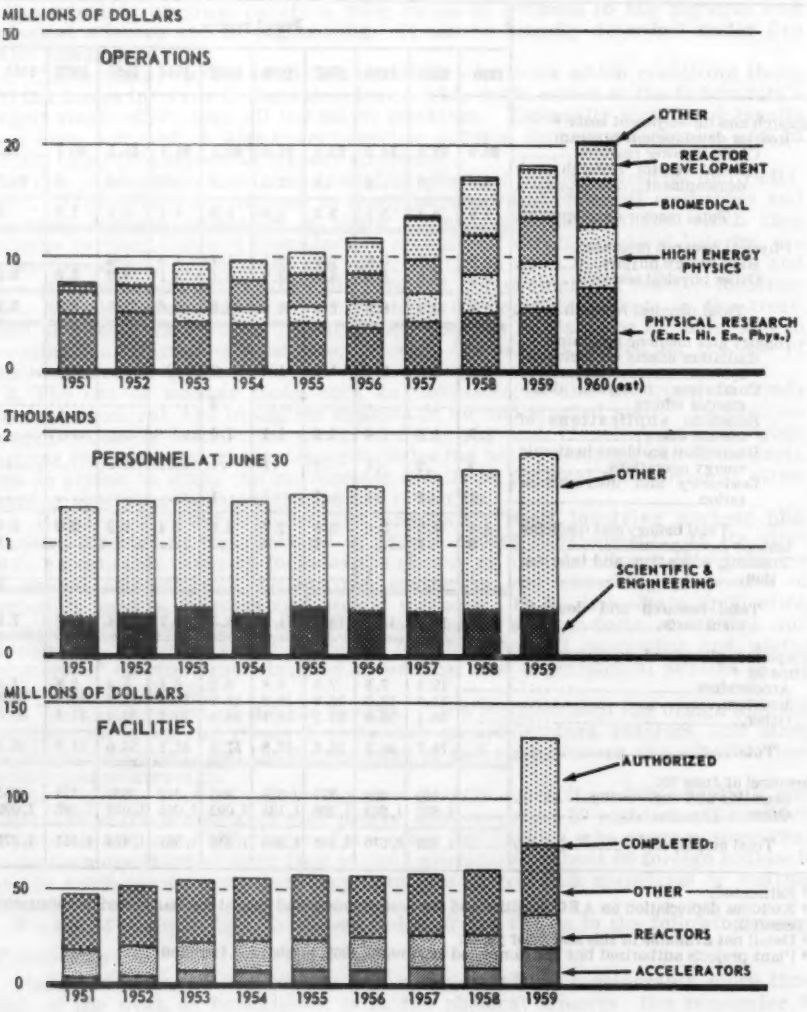
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Reactor development program:										
Civilian power reactors	$0.9	$3.5	$4.2	$2.8	$1.6	$1.1	$1.1	$1.1	$0.7	------
General reactor research and development	2.0	.9	.9	.9	1.0	.8	.6	.6	.5	$0.5
Total reactor development	2.9	4.4	5.1	3.7	2.6	1.9	1.7	1.7	1.2	.5
Physical research program:										
High energy physics	5.6	3.8	3.0	2.6	2.1	1.7	1.5	1.3	------	------
Other physical research	7.2	5.6	5.3	4.3	3.9	4.1	4.1	4.2	5.3	5.1
Total physical research	12.8	9.4	8.3	6.9	6.0	5.8	5.6	5.5	5.3	5.1
Biology and medicine program:										
Radiation effects on biological systems	2.2	2.3	2.0	1.6	1.4	.7	[3]	------	------	------
Combating radiation detrimental effects	------	------	------	------	------	.2	------	------	------	------
Beneficial applications of atomic energy	1.9	1.6	1.4	1.2	1.1	1.5	------	------	------	------
Biomedical problems in atomic energy operations	.2	.2	.1	.1	.1	.1	------	------	------	------
Dosimetry and instrumentation	.1	.1	.1	.1	.1	.1	------	------	------	------
Total biology and medicine	4.4	4.2	3.6	3.0	2.7	2.6	2.4	2.2	2.2	1.8
Isotope development	.3	.1	------	.1	.2	------	------	------	------	.1
Training, education, and information	.1	------	.1	------	------	------	------	------	------	------
Total research and development costs	20.5	18.1	17.1	13.7	11.5	10.3	9.7	9.4	8.7	7.5
Completed plant and equipment at June 30:[4]										
Accelerators	------	19.3	7.5	7.5	6.8	6.2	6.1	5.4	2.8	1.5
Reactors	------	17.0	17.0	16.9	16.9	16.9	16.9	16.8	16.8	16.5
Other	------	38.4	35.8	34.2	34.1	34.8	34.1	34.4	31.4	30.3
Total	------	74.7	60.3	58.6	57.8	57.9	57.1	56.6	51.0	48.3
Personnel at June 30:										
Scientific and engineering	------	440	408	379	368	366	342	331	319	285
Other	------	1,395	1,268	1,206	1,135	1,092	1,045	1,092	1,096	1,092
Total employees	------	1,835	1,676	1,585	1,503	1,458	1,387	1,423	1,415	1,377

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available in this and prior years.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $55.4 million.

BROOKHAVEN NATIONAL LABORATORY

RESEARCH AND DEVELOPMENT



Brookhaven National Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$17,141	$18,123	$20,500
Reactor development program, total	5,114	4,411	2,957
Civilian power reactor, total	4,239	3,475	877
Liquid metal fuel reactor research and development	4,165	3,360	750
Studies and evaluation	74	115	127
Nuclear technology and general support, total	875	936	2,080
Engineering physics and advanced reactor development	447	433	995
Reactor fuels and materials development	50	71	425
Reactor components			100
Separations development, total	378	432	450
Aqueous chemical process development	88	158	150
Residue treatment development	105	110	100
Residue disposal development	185	164	200
Reactor safety			110
Physical research program, total	8,282	9,396	12,758
Physics research program, total	5,138	6,089	8,470
High-energy physics	2,966	3,771	5,580
Nuclear structure and neutron physics	1,854	1,907	2,315
Design and development devices for physics research	272	266	305
Computer research and development	46	144	270
Chemistry research, total	2,339	2,427	3,033
Process chemistry	327	321	468
Chemical properties and reactions	1,916	2,019	2,450
Preparation and purification of special research materials	96	88	115
Metallurgy and material research, total	805	880	1,255
Alloy theory and nature of solids	648	741	1,025
Effects of irradiations on materials	157	139	230
Biology and medicine program, total	3,609	4,173	4,415
Radiation effects on biological systems, total	1,992	2,273	2,170
Medical research	1,275	1,471	1,450
Biological research	607	802	720
Biophysics research	110		
Beneficial applications of atomic energy, total	1,419	1,639	1,935
Cancer research	517	598	700
Medical research	373	424	425
Biological research	509	593	780
Distribution isotopes	20	24	30
Biomedical problems in atomic energy, total	88	133	170
Biophysics research	88		
Environmental research		133	170
Dosimetry and instrumentation, total	100	128	140
Dosimetry	80	89	100
Instrumentation	20	39	40
Civil effects test program, total	10		
Isotope development program, total	26	104	280
Radioisotope production and process development	9		
Industrial process radiation	17	104	280
Training, education, and information program, total	110	39	90
Assistance to schools	24	5	5
International conferences, exhibits, studies, and other assistance	43	5	55
Other training, education, and information activities	43	29	30

Research in basic chemistry currently represents approximately one-fourth of the research effort in the physical sciences program. The strong program in nuclear chemistry will continue. Radiation chemistry will be given relatively more emphasis, and the overall chemistry effort is expected to expand somewhat.

In metallurgy and solid state physics, some increases and diversification are anticipated. The currently contemplated expansion in metallurgy facilities is not expected to allow substantial expansion in this field, and only minor expansion is envisioned in solid state studies.

Biology program.—In the Biology Department, which constitutes about 40 percent of the total research effort in the life sciences at Brookhaven, there are at present about 20 staff scientists, 10 research associates, and an average of 15 visiting scientists engaged in the research program. It is anticipated that the research program will continue to expand, with the greater share of the increase being in the research associate and visitor categories.

The biology research program emphasizes research in genetics, radiation biology, molecular biology, mammalian physiology, and cellular physiology.

This Laboratory provides the Commission's principal facility for the cooperative programs in the application of radiation for crop improvement. No further expansion in this effort is anticipated. The research program in plant radiobiology will be expanded following the recommendation of an ad hoc committee of botanical scientists who recently examined critically the Commission's entire plant science research program. Since the existing program at Brookhaven is already quite strong in molecular biology, the expansion will emphasize cellular and whole-organ approaches.

It is anticipated that the general program in genetics will remain at about its present level of activity. Particular emphasis will be given to the effects of radioisotopes incorporated into the genetic materials. Strontium 90 may present a special problem in this regard since it can partially replace calcium in the molecular structure of chromosomes.

The radiation biology program has emphasized mammalian studies. Although the numbers of animals employed in radiation toxicity studies will not be greatly increased, there will be an expansion of the basic studies at the molecular and cellular levels necessary for understanding whole body radiobiological effects. Estimates of cell renewal and turnover times are important in predicting radiation effects on specific tissues of importance in maintaining the physiological levels of activity consistent with survival. Efforts in theoretical biology will be considerably expanded to aid in the prediction of radiobiological damage.

The molecular biology program will be strengthened by expansion of studies in free radical chemistry, of protein and nucleic acid biosynthesis and their interrelationships, of protein structure, and of the mechanism of enzyme action.

Medical program.—The program of nuclear medicine includes application of atomic components in the treatment and diagnosis of disease and in the elucidation of fundamental biological processes. During 1959 the medical reactor was brought into operation. Research and service activities are being directed at making maximum utilization of the reactor and its associated equipment in application to medical problems.

Many of the research problems confronting medical men today are so large and complex that a group assault is necessary. In view of the unique facilities, the special competence, and unusual associations at Brookhaven, every effort will be made to attack such complex medical problems; determination, testing, and utilization of the therapeutic advantages provided by a medical reactor is one example.

Nuclear technology.—Brookhaven National Laboratory contributes in all of the nuclear technology programs, though the overall level of effort is of moderate size. Significant increases, emphasizing advanced reactor concepts, are expected in reactor components and chemical separations programs, moderate increases are expected in fuels and materials and reactor physics programs, and the current level of support is expected to be continued in the sanitary and environmental engineering program and the reactor safety program.

Isotopes development.—Current planning contemplates expansion of the modest program in high-level radiation research and development. The high-level radiation program will experience significant changes in program emphasis during the next 10 years. These changes will, of course, depend on the results of research and development of large radiation source designs, radiation physics, chemonuclear reactors, high-level dosimetry, and engineering designs of high-level irradiators. The Brookhaven program will be concerned primarily with

the more fundamental aspects of applied radiation chemistry, physics, and engineering necessary to supplement and accelerate an industrial radiation program.

Oak Ridge National Laboratory

Oak Ridge National Laboratory developed around the facilities established to scale up the plutonium project work started at the metallurgical laboratory in Chicago. The first laboratory facilities at Oak Ridge were the reactor for production of gram quantities of plutonium and a pilot chemical plant for separation of plutonium from irradiated uranium. Virtually from the start, this work was supplemented by basic physical research and by development assignments. Biology and medicine programs also were undertaken early, to begin to explore the hazards associated with these new materials and with radiation. The basic orientation of Oak Ridge National Laboratory toward chemical technology and process development which began with its original mission has persisted. Likewise, the emphasis on neutron physics, research and test reactors, as well as power reactor development and isotope production was a natural course for the postwar program, centered as it was around the graphite reactor, now the oldest operating nuclear reactor in the world.

The Laboratory has grown by expansion of its projects in these historical fields of research, by absorption of the wartime electromagnetic development laboratory, and by assignment of major project responsibilities, such as the aircraft nuclear propulsion project, as well as by gradual strengthening of existing basic research programs. As a result, the Laboratory's interests and skills have continually widened until it is now involved in research and development in most fields of Commission activity.

The Laboratory's mission is weighed on the side of applied research, development, and isotope preparation, with about 75 percent of the budget going into these activities. The Laboratory is the country's central establishment for producing both stable and radioisotopes, the latter both in a wide variety for research and medical therapy and also in large quantities for industrial use. The two largest areas of applied work are reactor development and chemical processing.

The applied program of the Laboratory involves the following major efforts:

Thermal breeding.—In accord with the Commission's overall reactor program in which breeding is a major long-range objective. Oak Ridge has been assigned the responsibility for developing the thermal breeder systems.

Gas-cooled reactor.—The Laboratory has the responsibility for technical aspects of the gas-cooled reactor program, including technical features of the 85-megawatt (thermal) reactor to be built in Oak Ridge and the continuing research program in gas-cooled reactor technology. This is an example of a role which the major laboratories may be expected to play to an increasing extent; i.e., to serve as the Commission's center of know-how and research on the major types of power reactors.

Technical assistance.—The Laboratory provides to the Commission technical assistance on specific reactor problems, ranging from conceptual design of the Army package power reactor, now operating at Fort Belvoir, to general responsibility for the shielding portion of the aircraft nuclear propulsion program. In addition, assistance is now being provided on the maritime reactor program (NS *Savannah*), the Puerto Rican reactor, the small powerplant program, and the Enrico Fermi reactor.

General reactor development.—To provide the bases for continued growth and improvement in the power reactor field, the Laboratory carries on research or development in metallurgy, chemistry, and solid state physics aimed at improving reactor fuel elements and construction materials; in electronics to improve reactor control and safety systems; and in engineering (*a*) to increase the knowledge of heat transfer and hydrodynamics and thus increase reactor performance, (*b*) to improve components, and (*c*) to evaluate the corrosive behavior of materials under reactor conditions. Contributing to general reactor development has been the succession of test reactors for which the Laboratory has been wholly or partially responsible; the low intensity testing reactor, the materials testing reactor, the swimming pool reactor, the tower shield reactor, and the Oak Ridge research reactor.

Chemical processing.—Beginning just after the war with the development of a solvent-extraction process for recovery of uranium from the Hanford waste tanks, the Laboratory has played a major role in devlopment of processes for extraction of plutonium, recovery of uranium from production reactors, and for

recovery of enriched fuel—the process used at the Idaho chemical processing plant. Most of the Laboratory's effort in chemical process development has now turned to processes for power reactor fuels. A pilot plant complex utilizing existing structures, supplemented by a new head-end treatment plant, will permit the Laboratory to process fuels from several of the power reactors in the course of the developmental program.

Waste disposal.—As an outgrowth of the necessity for providing safe means of disposal of its own radioactive wastes, the Laboratory is engaged in a broad study of safe and economical methods for disposal of gaseous, liquid, and solid wastes.

Controlled thermonuclear program.—The approach taken at Oak Ridge to this problem involves the injection, at high energy, of molecular ions through a carbon arc in a magnetic bottle. The atomic ions produced by breakup of the molecules in the arc are confined and, when proper conditions are achieved, may produce a continuous thermonuclear reaction. The attainment of these proper conditions in the DCX device is the focus of a sizable program at the Laboratory.

The basic research work of Oak R'dge National Laboratory, though representing not more than 25 percent of the whole budget, is actually very large, involving over 600 scientific man-years of effort out of a total of about 1,450. The fields covered range, for example, from radiobiology to mathematics, from plasma physics to solid state physics.

Physics.—A large fraction of the physics research is concerned with the reactions of neutrons, especially those pertinent to reactor development, or the utilization of neutrons as tools for research. Thus, the Laboratory has broad programs to determine nuclear cross sections, to investigate the interactions of radiations with matter, and to determine the structure of crystals as disclosed by the diffraction of neutrons.

Chemistry.—The Laboratory is concerned with the chemistry of the fission process, fission products, chemical effects of radiation, and chemical properties and reactions in aqueous and nonaqueous media at high temperatures.

Metallurgy and solid state physics.—This work is concentrated on the fundamental properties and reactions of metals, ceramics, semiconductors, and organic materials, primarily under conditions encountered in nuclear reactors.

Biological sciences.—The major problems studied in this field are those central to the use of nuclear energy, the investigation of the biological effects of radiation and the development of means to alleviate or counteract such effects. An extensive program is concerned with elucidating the genetic consequences of exposure to radiation.

The Oak Ridge National Laboratory is operated by the Union Carbide Nuclear Co. under contract to the Commission. A good example of the Laboratory's capability to perform functions of a semi-industrial character was the coordination of the U.S. Sherwood exhibit at Geneva in 1958.

The Laboratory is in the midst of a $45 million building program which, upon completion, will provide outstanding facilities for advanced work and adequate space for the staff. The Laboratory is equipped with several research reactors, chemical pilot plants, cyclotrons, and Van de Graaff accelerators, and plans are now underway for construction of an ultra-high-performance isotope-producing reactor which will be used for manufacturing very heavy isotopes in large quantities for research purposes.

Future plans

It is anticipated that the size of the Oak Ridge National Laboratory staff will be generally stable during the next 10 years.

Reactor program.—The civilian reactor work at Oak Ridge is presently in the areas of gas-cooled reactors and thermal breeders. Research and development on the gas-cooled reactor system will be continued at about the present level for the next several years, at which time evaluation of the economic potential of the system will determine the future course and volume of the work. Thermal breeding is a long-range program; the work will be conducted at a gradually increasing rate during the decade, unless favorable results warrant more rapid expansion.

Oak Ridge National Laboratory: 10-year trend—Costs, staff, and facilities

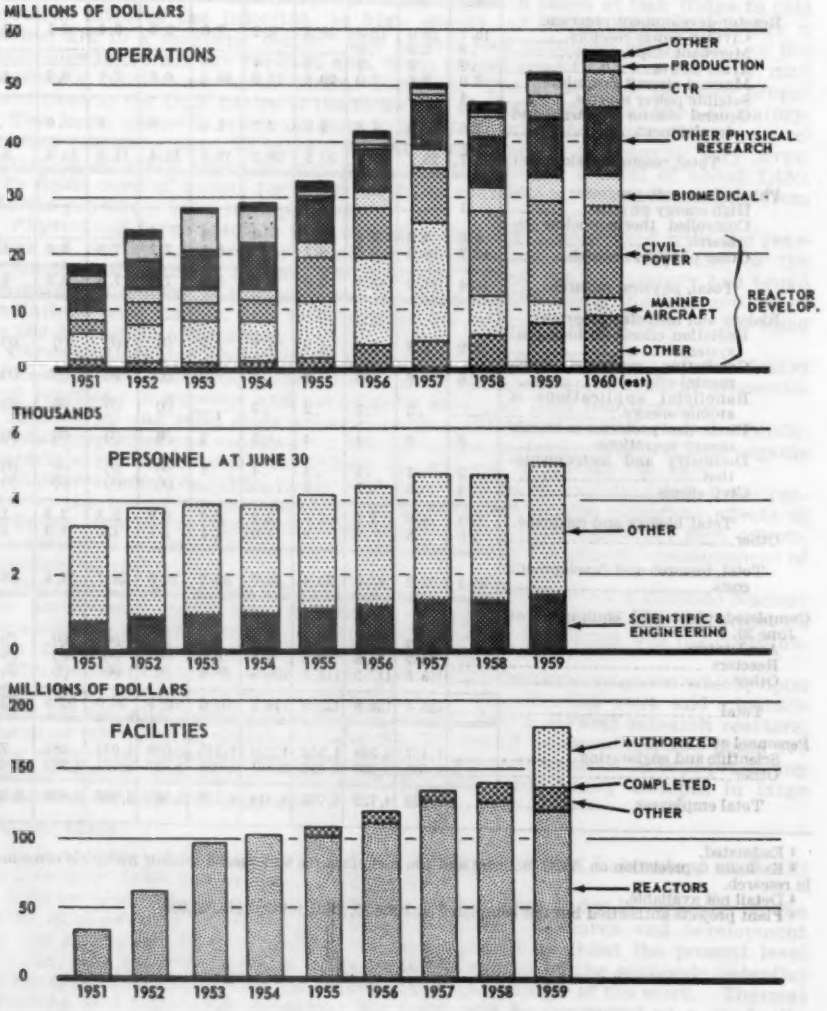
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	$2.5	$2.8	$1.8	$1.3	$1.2	$1.3	$6.4	$6.7	$3.1	$1.6
Reactor development program:										
Civilian power reactors	16.7	18.0	15.3	10.2	9.2	7.6	3.8	3.4	4.1	2.3
Merchant ship	.8	1.2	.3	------	------	------	------	------	------	------
Army power	.2	.2	.6	.5	.4	.4	------	------	------	------
Manned aircraft propulsion	3.0	3.6	7.0	20.6	15.9	10.0	6.7	7.1	6.5	4.8
Satellite power sources	.4	.5	------	------	------	------	------	------	------	------
General reactor research and development	7.6	5.6	4.3	4.0	2.7	1.4	.9	.5	.6	.9
Total, reactor development	28.7	29.1	27.5	35.3	28.2	19.4	11.4	11.0	11.2	8.0
Physical research program:										
High energy physics	.1	------	------	------	------	------	------	------	------	------
Controlled thermonuclear research	5.6	4.0	3.4	.9	.6	.4	.1	------	------	------
Other physical research	12.7	10.9	9.7	8.7	8.0	8.1	7.7	7.5	6.0	4.8
Total, physical research	18.4	14.9	13.1	9.6	8.6	8.5	7.8	7.5	6.0	4.8
Biology and medicine program:										
Radiation effects on biological systems	3.2	2.8	2.5	1.9	1.7	1.5	(3)	(3)	(3)	(3)
Combating radiation detrimental effects	.6	.6	.3	.3	.3	.2	(3)	(3)	(3)	(3)
Beneficial applications of atomic energy	------	.3	.2	.2	.2	------	(3)	(3)	(3)	(3)
Biomedical problems in atomic energy operations	.8	.5	.4	.4	.3	.3	(3)	(3)	(3)	(3)
Dosimetry and instrumentation	.2	.1	.1	.4	.4	.4	(3)	(3)	(3)	(3)
Civil effects	.4	.3	.2	.1	------	------	(3)	(3)	(3)	(3)
Total, biology and medicine	5.2	4.6	3.7	3.3	2.9	2.4	2.3	2.3	2.2	1.9
Other	1.0	.8	.9	.9	1.0	1.1	1.1	1.2	1.9	1.9
Total, research and development costs	55.8	52.2	47.0	50.4	41.9	32.7	29.0	28.7	24.4	18.2
Completed plant and equipment at June 30:[4]										
Accelerators	------	6.2	7.1	7.0	3.9	2.5	(3)	(3)	(3)	(3)
Reactors	------	15.7	14.8	9.3	8.4	6.9	(3)	(3)	(3)	(3)
Other	------	113.5	117.9	118.7	106.8	97.6	(3)	(3)	(3)	(3)
Total	------	135.4	139.8	135.0	119.1	107.0	102.8	99.0	62.9	33.3
Personnel at June 30:										
Scientific and engineering	------	1,457	1,398	1,350	1,223	1,143	1,028	1,011	884	763
Other	------	3,566	3,330	3,413	3,191	3,035	2,943	2,974	2,952	2,494
Total employees	------	5,023	4,728	4,763	4,414	4,178	3,971	3,985	3,836	3,257

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $45,000,000.

OAK RIDGE NATIONAL LABORATORY

RESEARCH AND DEVELOPMENT



Oak Ridge National Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$46,752	$52,137	$55,763
Production process development, total	1,772	2,797	2,500
Reactor development, total	27,548	29,048	28,696
Civilian power reactors, total	15,308	17,964	16,700
Pressurized water reactor—research and development			250
Gas cooled reactor—research and development	1,139	5,331	9,250
Fluid fuel reactors, total	13,880	12,554	6,900
Homogeneous reactor, total	11,397	9,663	4,900
Research and development	9,416	7,813	2,900
Operations	1,981	1,850	2,000
Fused salt reactor—research and development	2,483	2,891	2,000
Studies and evaluation	289	79	300
Nuclear technology and general support, total	4,315	5,632	7,621
Thermal reactor safety	172	327	380
Engineering physics and advanced reactor development	578	1,188	1,867
Reactor fuels and materials development	571	1,075	1,779
Reactor components development		60	240
Aqueous chemical processing development	1,666	1,685	1,500
Volatility processing development	462	432	805
Low decontamination studies	60		
Residue disposal development	806	865	1050
Maritime pressurized water reactor, total	273	1,235	775
Army power reactors, total	612	161	200
Stationary medium power	161		
Gas cooled reactor systems	451		
General support		161	200
Airplane propulsion reactors, total	7,040	3,582	3,000
Indirect cycle	2,227		
General support	4,813	3,582	3,000
Auxiliary power sources, SNAP I		474	400
Physical research program, total	13,076	14,919	18,363
Physical research, total	3,082	3,924	4,649
High energy physics		56	100
Nuclear structure and neutron physics	2,273	2,416	2,591
Extra-nuclear properties of matter	193	192	160
Design and development of devices for physics research	290	550	945
Physical methods of isotope separation	289	676	813
Computer research and development	37	32	40
Chemistry research, total	5,510	5,711	6,315
Process chemistry	2,719	2,471	2,321
Chemical properties and reactions	2,230	2,417	2,705
Chemical isotope separation studies	255	318	479
Special projects	176	333	505
Preparation and purification of special research materials	130	171	305
Metallurgy and materials research, total	1,146	1,304	1,829
Production, treatment, and properties of materials			69
Alloy theory and the nature of solids	713	762	865
Effects of irradiations on materials	433	541	895
Controlled thermonuclear research, total	3,338	3,980	5,570

Oak Ridge National Laboratory: Current budget and recent costs by categories of work—Continued

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Biology and medicine, total	$3,660	$4,588	$5,203
Radiation effects on biological systems, total	2,453	2,824	3,195
Biological research	2,063	2,408	2,782
Biophysics research	390	416	413
Combating radiation detrimental effects, total	328	600	618
Biomedical problems in atomic energy operations, total	420	503	827
Biophysics research	251	305	571
Environmental research	109	198	256
Dosimetry and instrumentation, total	64	102	225
Dosimetry	64	56	90
Instrumentation		46	135
Civil effects test program, total	161	279	338
Beneficial applications of atomic energy	234	280	
Isotope development program, total	263	455	570
Radioisotope and process development	263	382	570
In fiscal year 1959, ORNL included start-up costs in isotope program		73	
Training, education, and information program, total	433	335	431
Operation of schools	284	198	(1)
Assistance to schools	47	33	
International conferences, exhibits, studies and other assistance	33	43	
Other training, education and information activities	69	61	

[1] Detail not available.

Oak Ridge is a large contributor in all areas of nuclear technology—chemical separation and development, fuels and materials, reactor components, reactor physics, and sanitary and environmental engineering. The current level of effort is expected to be maintained or increased during the 10-year period. Minor changes in emphasis will occur within the overall program, with the largest increase in the reactor components development program.

Support for the aircraft nuclear propulsion program is expected to continue.

Physical science program.—**In basic physics, the Laboratory over the next 10 years will continue to supply much of the nuclear data fundamental to the whole technology; this task will be made easier by the new Oak Ridge relativistic isochronous cyclotron, and by the acquisition of a 10 Mev. Van de Graaff accelerator. The Laboratory will venture somewhat further into high energy physics, though these steps will be taken carefully so that the demands in this field do not reduce capacity to perform precision work in the binding energy region.**

Basic chemistry, solid state physics, and mathematics will continue much as they have been with shifts in emphasis needed to shore up the applied programs. The addition of the new cyclotron and the high flux isotope reactor will stimulate research in heavy element chemistry, and in this field some expansion is anticipated. In metallurgy, expanded effort is expected in metal physics and ceramics research. Space limitations will probably keep solid state studies at their present size. Expansion is anticipated in the materials research program, making use primarily of existing personnel and facilities.

Controlled thermonuclear research should develop naturally over the next decade along the lines already established—high energy injection into a mirror geometry. It may take 5 years to bring the science of plasma physics to a point where it will be possible to assess realistically the outlook for fusion power. The projections must, therefore, be considered very tentative and almost sure to be modified as more information is acquired. It appears probable that the Commission may call on Oak Ridge for direct collaboration with other controlled thermonuclear laboratories. For example, if it becomes necessary to inject ions into a stellarator, a joint effort on the part of Princeton and Oak Ridge might be desirable.

Biological research program.—It is anticipated that the total biological research effort will be somewhat increased, especially in the plant science and pathology-physiology areas. A large-scale study of the effects of low level radiation in mice is planned. No major new facilities are anticipated, although existing facilities will need modification. The increase in personnel engaged in biological research will be minor compared to the total personnel of the laboratory.

The large project in cytology and genetics emphasizes basic studies of cellular structure and function, and of the action of radiation on the cell and especially on the genetic apparatus. This program will continue at the present level.

Oak Ridge is the site of the Commission's major program in mammalian genetics. Work here has recently shown that the induction of gene mutations occurs at a lower rate when the radiation exposure is protracted over a long period at a low dose rate. This is extremely significant to consideration of the genetic hazards of fallout and occupational exposures. The present level of activity will continue although new projects will be initiated as major studies are completed.

In the mammalian recovery work, laboratory studies of protection by chemicals and by bone marrow transplantation in the mouse have been emphasized. The program has developed into a broader one concerned with tissue transplantation in general, with emphasis upon related immunological problems. No expansion of effort is planned.

The pathology-physiology studies have been concerned with the pathogenesis of early and delayed somatic radiation effects in mammals with emphasis on the induction of leukemia and neoplasia. This program will be expanded to encompass the life shortening and carcinogenic effects in mice of chronic low-level radiation.

The major objective of the work in cell physiology is the determination of the molecular basis of cell function. The findings will provide a background to facilitate determination of the effects of radiation and other insults on cellular function. No major increase in this program is anticipated.

The biophysics research is concerned with the understanding of the basic primary physical and chemical events which underlie and govern the action of radiation in biological systems. Significant advances have been made by the application of electron spin resonance methods to biological materials. It is anticipated that these studies will be expanded in conjunction with an overall increase in Commission supported effort in biophysics and bioenergetics.

Radiation immunology investigations are concerned with the fundamental immunological aspects of bone marrow and other tissue transplantation, and with fundamental immunological investigations. A modest expansion is planned, with emphasis on the immunogenetic aspects of the problems.

The biochemistry projects at the laboratory have been concerned with three major problems: intermediary metabolism in bacteria and plants, nucleic acid biochemistry, and protein synthesis. Considerable expansion is planned with emphasis on the interrelationships and genetic control of nucleic acid and protein biosynthesis, biochemical studies of gene action, and studies of cellular differentiation at the molecular level.

Ecological studies are being conducted on control areas and areas contaminated by waste disposal operations. Emphasis is on determining the concentration and distribution of fission products in the soil, plant, and animal components of various environments. The studies are in four major areas: (1) White Oak Lake bed, (2) mammalian, (3) forest, and (4) the Clinch River. It is anticipated that this program will be somewhat expanded.

Isotope program.—Current planning contemplates modest expansion of the program level during the next 5 years, after which the effort will diminish gradually during the latter part of the decade. An increased effort during the early years is needed to develop information about the physical and chemical properties of radioisotope products. An accelerated process development program is also required to make new radioisotopes available and to increase the purity, yield, and quantity of radioisotopes currently available. The long-range program is directed toward development of information to stimulate applied research in industrial laboratories.

Oak Ridge Institute of Nuclear Studies

The Oak Ridge Institute of Nuclear Studies is a nonprofit corporation of 37 southern universities and colleges. The institute serves as a device for facili-

tating research and training relationships between Oak Ridge National Laboratory and the universities, in addition to conducting programs of its own. Though not a multiprogram laboratory (its research activities being limited to the medical field) it is included here because of its close ties to Oak Ridge National Laboratory. The institute consists of four divisions: Medical, special training, university relations, and museum.

The medical division was formally organized in January 1949 as a research unit, the broad interests of which are directed toward the preliminary investigation of promising possibilities in the application of radioactve substances to the study of cancer and related disease. It was located in Oak Ridge with the intent of developing a medical center which would exploit the special research opportunities of that location. The presence and personal interest of a large staff of outstanding electronic, nuclear instrumentation and isotope production specialists of the Oak Ridge National Laboratory has contributed greatly to the successful pioneer work in radioisotope therapy, teletherapy design, and patient treatment.

A primary reason for establishing a clinical research program at Oak Ridge was the availability of short-lived isotopes from the reactors. The extensive clinical evaluation of gallium–72 with a half life of 14 hours is an example of a study carried out at the institute that would have been impossible to undertake at a more distant location from an isotope-producing reactor. Currently, the efforts in the clinical program are directed toward the internal use of promising isotopes plus studies involving external irradiation followed by bone marrow transplantation. Extensive basic and preclinical studies are being pursued in an effort to learn more about the distribution and metabolism of isotopes in man in the diseased state. Thus far, over 1,000 patients have been admitted for treatment.

An accompaniment of this program is the training of physicians and scientists from the United States and foreign countries. One hundred and forty-four American physicians and 27 from other nations have spent from 3 months to 2 years in the medical division, in addition to 36 scientists in the life sciences.

It is contemplated that the medical division will continue to operate at about the present level of effort for the coming decade. The completion of the whole-body irradiation facility will undoubtedly lead to an expanded fundamental study on the effects of whole-body irradiation with perhaps less emphasis on the use of new isotopes. The new facilities will permit radiation to be directed at patients from several directions with a resulting more uniform dose distribution. Efforts will be continued to develop biological tests that will help in determining doses so that persons exposed to known or unknown amounts of radiation can be properly evaluated and treated.

Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.: 10-year trend—Costs, staff, and facilities

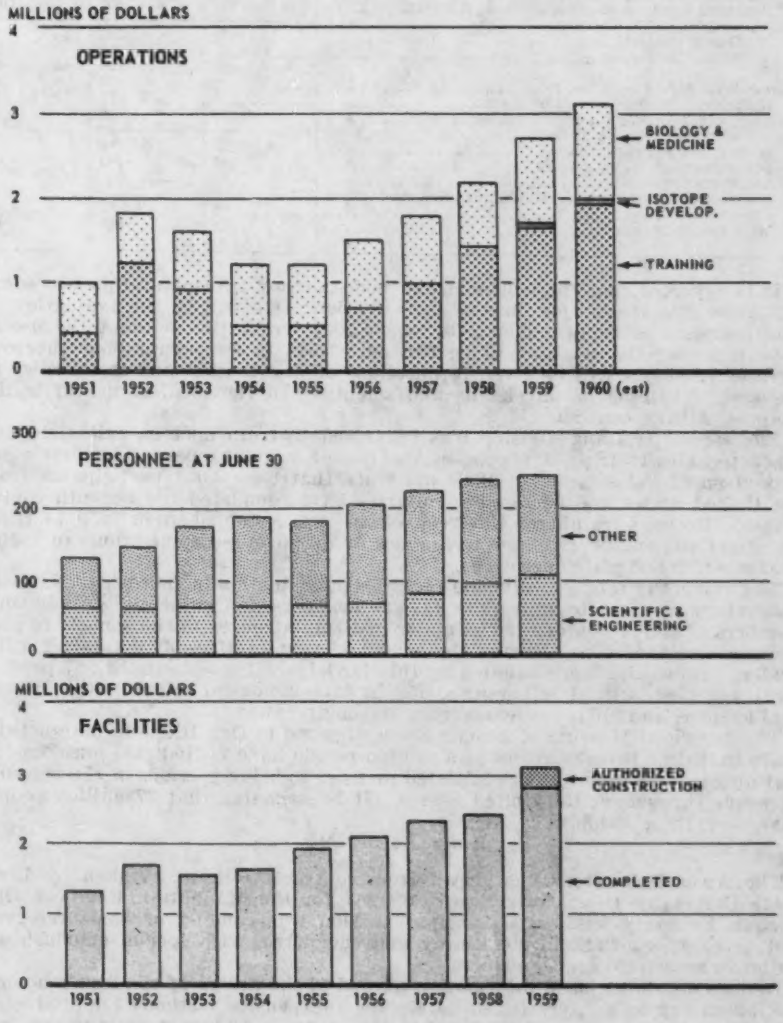
[Dollar amounts are in millions]

	Fiscal years—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development:[2]										
Biology and medicine	$1.1	$1.0	$0.8	$0.8	$0.8	$0.7	$0.7	$0.7	$0.6	$0.6
Isotope development	.1	.1								
Training, education, and information	1.9	1.6	1.4	1.0	.7	.5	.5	.9	1.2	.4
Total, research and development costs	3.1	2.7	2.2	1.8	1.5	1.2	1.2	1.6	1.8	1.0
Completed plant and equipment at June 30:[3] All other, total		2.8	2.4	2.3	2.1	1.9	1.6	1.5	1.7	1.3
Personnel at June 30:										
Scientific and engineering		105	98	80	69	63	62	61	60	60
Other		140	139	143	136	121	127	111	86	69
Total employees		245	237	223	205	184	189	172	146	129

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $0.3 million.

OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

RESEARCH AND DEVELOPMENT



Oak Ridge Institute of Nuclear Studies: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$2,249	$2,654	$3,120
Biology and medicine program, total	871	962	1,055
Beneficial applications of atomic energy, total	871	962	1,055
Cancer research	871	746	784
Medical research		216	271
Isotope development program, total		73	116
Radioisotope technology training		73	116
Training, education and information program, total	1,378	1,619	1,949
Operation of schools	231	196	212
Fellowships	534	793	1,080
Assistance to schools	4		30
International conferences, exhibits, studies, and other assistance	8	17	25
Museums and exhibits	601	613	602

It is expected that the leukemia and bone-marrow transplantation procedure will grow into two major lines of investigation: One will be the evaluation of the treatment of acute leukemia by whole-body irradiation without the use of bone marrow; the second will be further efforts to transplant bone marrow. Greater emphasis will be given to questions of distribution and metabolism of isotopes. Training of physicians and scientists in the medical use of radioisotopes will be continued.

The special training division was organized to train doctors, scientists and other technically trained people in the use of radioisotopes. The first class was given in the summer of 1948 and since that time 3,000 participants from the United States and 54 foreign countries have completed the 1-month course of basic isotopes training. A 6-week course was established in 1950 to train scientists and engineers in the techniques of radioisotope applications in industrial research and plant operations.

The university relations division facilities participation in Oak Ridge National Laboratory research by university faculty members and students. In addition, members of the laboratory travel under institute auspices to the schools to give lectures and seminars. During the academic year of 1958–59, a total of 1,701 student fellowships were handled by this Division. These included 987 predoctoral and postdoctoral fellowships, 452 in radiobiological science, 46 in industrial hygiene, and 216 in nuclear science and engineering.

The American Museum of Atomic Energy opened in Oak Ridge in March 1949. Since that time three-quarters of a million people have visited this museum. A traveling exhibit program was initiated in order to bring portions of the museum to people throughout the United States. It is estimated that 27 million people have seen these exhibits.

Ames Laboratory

The Ames Laboratory has grown from contract work undertaken by Iowa State University (then Iowa State College) for the Manhattan Engineer District in February 1942. Its principal mission was conduct of basic research and development work in metallurgy and chemistry, with special emphasis on the lesser known elements and metals.

Besides obtaining basic information needed in the design of the first reactors, the laboratory was successful in developing inexpensive methods for producing very pure uranium metal. These processes were turned over to industry and are still in use today. While the industrial producers were being established, Ames produced over 2 million pounds of metallic uranium for experimental use and for the early reactors.

Other projects on which the laboratory has worked include development of technology concerning uranium and its alloys, including a very much cheaper method of casting the metal; development of a process, now used industrially, for producing metallic thorium; and processes for separating the rare earths

and for producing the pure rare earth metals. These processes, too, are now in industrial production.

The Ames Laboratory maintains strong groups in basic inorganic chemistry, solid state physics, physical and chemical metallurgy, surface chemistry, kinetics (rates of reactions), ion exchange, structural chemistry, etc., and it is from these basic studies that the applications mentioned above developed. Work is also carried on in nuclear physics and nuclear chemistry.

The Laboratory maintains a vigorous program in high temperature metallurgy and has strong analytical groups to develop methods for analysis of the unusual materials dealt with in the program.

The Laboratory is housed in two Commission-built structures on campus land leased from Iowa State University. A third Commission building, the metals development building, is under construction at present, and a research reactor facility is in design.

The laboratory is close to the campus more than by reason of location alone; its research staff is made up, to a substantial extent, of personnel who spend part time at the laboratory and part time in academic pursuits. They range from senior professors to graduate students. Thus, the laboratory plays a significant training role, and benefits from close interrelation with academic research. Over 240 Ph. D.'s and nearly 220 M. S.'s have been granted by Iowa State on the basis, in part, of work done at the Ames Laboratory.

Ames Laboratory, Ames, Iowa: 10-year trend—Costs, staff, and facilities

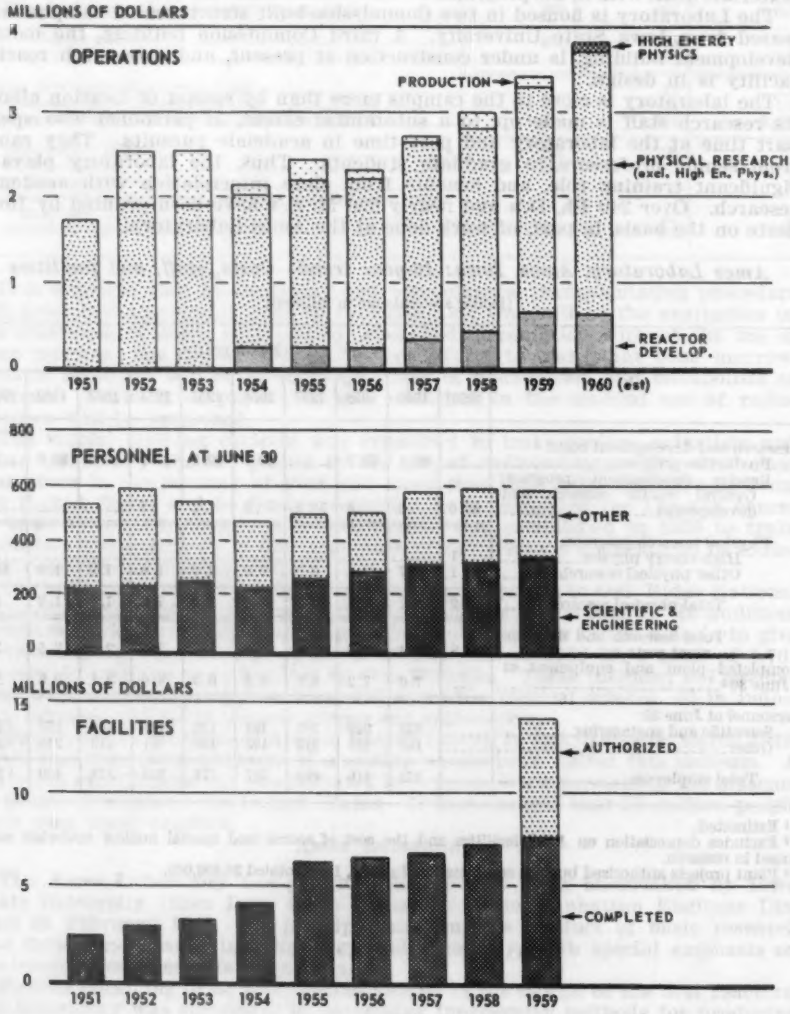
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	------	$0.1	$0.2	------	$0.1	$0.2	$0.1	$0.6	$0.6	------
Reactor development program:										
General reactor research and development	$0.6	.6	.4	$0.3	.2	.2	.2	------	------	------
Physical research program:										
High energy physics	.1	------	------	------	------	------	------	------	------	------
Other physical research	3.1	2.7	2.4	2.3	2.0	2.0	1.8	1.9	1.9	$1.7
Total physical research	3.2	2.7	2.4	2.3	2.0	2.0	1.8	1.9	1.9	1.7
Total research and development costs	3.8	3.4	3.0	2.6	2.3	2.4	2.1	2.5	2.5	1.7
Completed plant and equipment at June 30[3]	----	7.6	7.2	6.7	6.5	6.3	4.0	3.1	2.8	2.3
Personnel at June 30:										
Scientific and engineering	------	233	219	207	194	176	147	162	157	[1] 150
Other	------	190	197	212	193	198	191	213	243	[1] 220
Total employees	------	423	416	419	387	374	338	375	400	[1] 370

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $6,400,000.

AMES LABORATORY

RESEARCH AND DEVELOPMENT



Ames Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$2,993	$3,418	$3,836
Production process development	130	80	
Reactor development, total	388	615	645
Nuclear technology and general support, total	388	615	645
Reactor fuels and materials development	318	536	575
Separations, development program	70	79	70
Physical research program, total	2,445	2,716	3,191
Physics research, total	233	236	288
High energy physics	41	39	65
Nuclear structures and neutron physics	192	197	223
Chemistry research, total	1,315	1,445	1,600
Process chemistry	177	202	223
Chemical properties and reactions	1,056	1,119	1,326
Chemical isotope separation studies	82	125	141
Metallurgy and materials research, total	897	1,034	1,213
Production treatment and properties of materials	246	352	419
Alloy theory and the nature of solids	651	682	794
Effects of radiations on materials			
Training, education, and information programs, total	21	7	
Summer institute for engineering faculty	21	7	

Future plans

The completion of the metals development building and the Ames Laboratory Research Reactor will round out facilities needs as currently foreseen. Completion of these facilities will not mean a corresponding increase in personnel; the total increase now anticipated over the coming 10 years is quite modest.

While no major changes in the overall objectives of Ames are envisoned for the foreseeable future, the availability of the metals development building in late 1960 will greatly enhance its ability to produce quantities of highly pure metals and alloys and will also free space for basic research. In addition, the availability of the Ames Research Reactor will remove a serious limitation imposed upon the laboratory's ability to study the nuclear properties of solids.

Research programs in the field of reactor development will consist of work on metals, alloys, and ceramics. Emphasis will be concentrated on metals such as thorium and its alloys, yttrium and its alloys, rare-earth metals and their alloys, properties of metals and ceramics at temperatures above 1,000° C., effect of nonmetallic impurities on metal properties, the measurement of engineering properties such as fatigue and corrosion rate at relatively high temperatures, new pyroprocessing techniques, and the measurements of physical properties at high temperatures.

Fundamental research in the physical sciences will continue in physical chemistry and metallurgy. Work in high energy physics will continue to use nuclear emulsions, although it may be supplemented by the use of solid luminescence chambers. Work in nuclear structure and neutron physics will continue to take advantage of the unique characteristics of the Iowa State Synchrotron.

Chemistry research will consist of fundamental studies on the mechanism of various separation processes such as ion exchange, solvent extraction, and sublimation as well as the development of analytical and spectrochemical analytical methods.

Future work in metallurgy and materials research and solid state physics will take advantage of new techniques such as de Haas-van Alphen effect measurements on single crystals, the use of ionic crystals, the measurement of magnetoacoustic effects on metallic crystals at cryogenic temperature, high-pressure work, and the measurement of fundamental properties that will help determine the real nature of the solid state.

The laboratory will continue to develop fundamental pyrometallurgical data in support of low-decontamination, closed cycle separations systems. Advanced metallurgical studies will be continued in the development of alloys for nuclear energy applications. The level of effort will gradually be expended in materials development, but the program will remain relatively small in the overall materials development program.

Lawrence Radiation Laboratory

Renamed in honor of the late Ernest O. Lawrence, the University of California's Lawrence Radiation Laboratory has two major branches: one, at Berkeley, engaged largely in basic research; the other, at Livermore, engaged largely in applied research and developmental work. The two branches are discussed separately in the following pages.

Lawrence Radiation Laboratory—Berkeley

The Lawrence Radiation Laboratory at Berkeley has developed, with the support first of the State of California and private sources and later of the Government through the Manhattan Engineering District and the Commission, from the radiation laboratory established by Prof. Ernest Lawrence at the University of California in 1936. Much of the present character of the laboratory derives from this historical background. It still maintains close connections with the academic departments of the university, and is oriented toward basic research, with a strong interest in graduate and postdoctoral training.

Early in the Manhattan project the Laboratory devised and developed the calutron for separation of isotopes, and assisted in the design and construction of the electromagnetic separation plant at Oak Ridge which used the calutron technique for the first separation of uranium 235 from normal uranium. The Laboratory also discovered the element plutonium, and undertook work on its chemistry prior to transfer of plutonium chemistry responsibilities to the metallurgical laboratory at Chicago.

The Laboratory started with the cyclotron idea, and its activities are still largely centered around the development of and research with particle accelerators and their products. Nuclear physics at low and high energy, radiochemistry, and radiobiology are obvious applications. These led naturally into broader fields in physics, chemistry, biology, and medicine. The Berkeley Laboratory is particularly noted for its high-energy nuclear physics and for its work in the transuranic elements, many of which were discovered there.

The accelerators now operating at the laboratory are the bevatron (6.2 billion electron volts), the synchrocyclotron (740 million electron volts), the electron synchrotron (350 million electron volts), the 60-inch cyclotron, and the heavy ion linear accelerator (Hilac). Under construction is a high-current spiral ridge cyclotron, which will replace the 60-inch cyclotron.

Experimental physics is the largest division of the Laboratory. It is engaged almost entirely in high-energy physics, which investigates the elementary particles, and is an extremely active and growing field. In addition to large accelerators, it needs large and elaborate observing equipment, such as bubble chambers.

Work on controlled thermonuclear reactions is carried on in conjunction with the program centered at Livermore.

The theoretical group covers a wide range of activities: elementary particle theory, nuclear structure, accelerator theory, magnetohydronamics, etc. Part of this work is in support of Livermore activities.

The chemistry division is concerned with transuranic elements, nuclear spectroscopy, systematics of nuclear reactions and radioactivity, and some general chemistry.

The biomedical division is concerned with radiation biology, use of radioactive tracers, therapeutic use of radiation, and related fields. The bio-organic division started with the use of radiocarbon in studies of photosynthesis; now it covers a wider range in the field of molecular biology.

Future plans

Current planning for the Lawrence Radiation Laboratory, Berkeley, envisions a major increase in staff strength by the end of the 10-year period. Laboratory strength as of the end of fiscal year 1960 is expected to be somewhat greater than 2,300.

Lawrence Radiation Laboratory (Berkeley), Berkeley, Calif.: 10-year trend—Costs, staff, and facilities

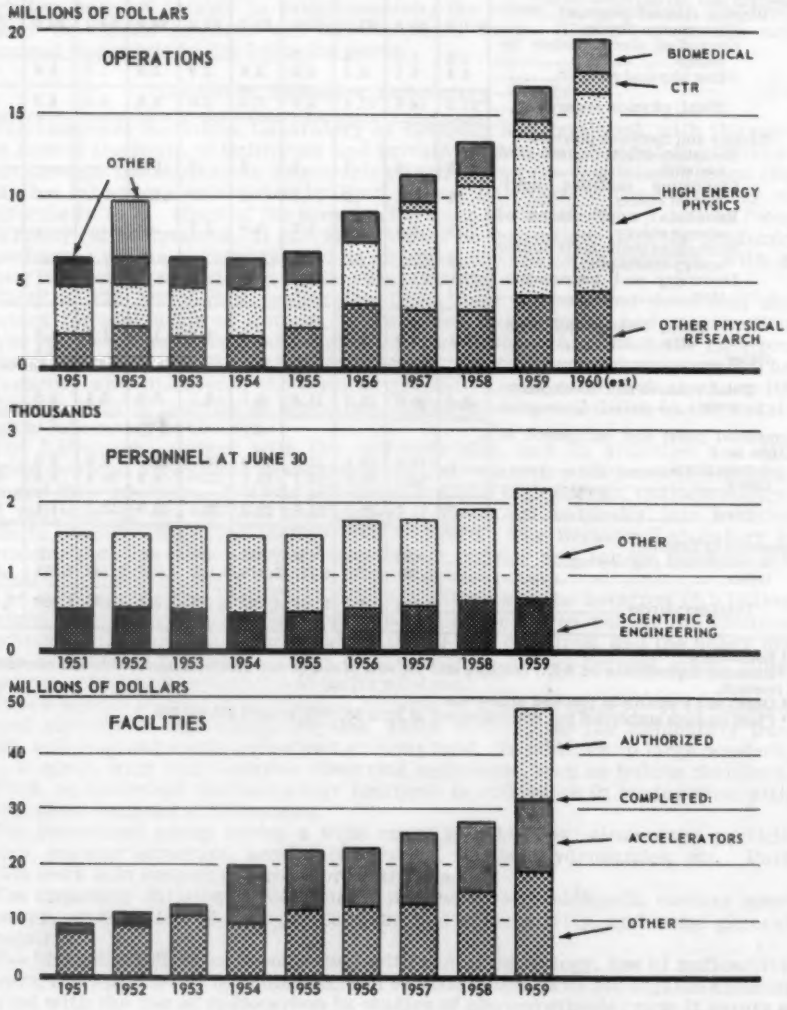
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Physical research program:										
High energy physics	$11.8	$9.5	$7.3	$5.9	$3.7	$2.8	$2.8	$3.0	$2.5	$2.8
Controlled thermonuclear research	1.3	1.0	.8	.5	------	------	------	------	------	------
Other physical research	4.4	4.1	3.3	3.3	3.6	2.2	1.8	1.7	2.3	1.9
Total, physical research	17.5	14.6	11.4	9.7	7.3	5.0	4.6	4.7	4.8	4.7
Biology and medicine program:										
Radiation effects on biological systems	.5	.4	.2	.2	.2	.2	(3)	------	------	------
Combating radiation detrimental effects	.1	.1	.2	.1	.1	.1	------	------	------	------
Beneficial applications of atomic energy	1.2	1.4	1.4	1.2	1.4	1.3	------	------	------	------
Biomedical problems in atomic energy operations	.2	------	------	------	------	------	------	------	------	------
Dosimetry and instrumentation	.1	.1	.1	.1	.1	.1	------	------	------	------
Total, biology and medicine	2.1	2.0	1.9	1.6	1.8	1.7	1.7	1.7	1.6	1.5
Other	------	------	------	------	------	------	------	------	3.4	.2
Total, research and development costs	19.6	16.6	13.3	11.3	9.1	6.7	6.3	6.4	9.8	6.4
Completed plant and equipment at June 30:[4]										
Accelerators	------	13.2	12.6	13.0	10.9	10.9	10.8	2.3	2.3	1.8
Other	------	18.5	15.0	12.7	12.1	11.6	9.2	10.4	8.8	7.4
Total	------	31.7	27.6	25.7	23.0	22.5	20.0	12.7	11.1	9.2
Personnel at June 30:										
Scientific and engineering	------	693	624	588	536	495	493	519	556	546
Other	------	1,501	1,283	1,177	1,173	1,029	1,048	1,149	1,024	1,035
Total employees	------	2,194	1,907	1,765	1,709	1,524	1,541	1,668	1,580	1,581

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available in this and prior years.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $16,400,000.

LAWRENCE RADIATION LABORATORY(Berkeley)

RESEARCH AND DEVELOPMENT



Lawrence Radiation Laboratory (Berkeley): Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$13,263	$16,687	$19,660
Physical research program, total	11,379	14,631	17,534
Physics research, total	7,698	10,023	12,200
High-energy physics	7,266	9,471	11,810
Nuclear structure and neutron physics	432	293	320
Design and development of devices for physics research		260	70
Chemistry research, total	2,887	3,538	4,034
Chemical properties and reactions, total	2,887	3,538	4,034
Controlled thermonuclear research	794	1,070	1,300
Biology and medicine program, total	1,855	2,040	2,126
Radiation effects on biological systems, total	204	400	575
Medical research	130	150	435
Biological research	37	121	140
Biophysics research	37	129	
Combating radiation detrimental effects, total	148	150	49
Medical research	55	89	49
Biophysics research	93	61	
Beneficial application of atomic energy, total	1,447	1,392	1,217
Cancer research	193	94	109
Medical research	864	791	634
Biological research	390	507	474
Biomedical problems in atomic energy operations, total			206
Medical research			130
Biophysics research			76
Dosimetry and instrumentation, total	56	98	79
Instrumentation	56	98	79
Training, education, and information, total	2	16	
International conferences, exhibits, studies, and other assistance, total	2	16	

Manpower.—The number of employees at Berkeley has increased from 1,200 to 2,200 in the last 10 years. There are a number of reasons for projecting a substantial increase in size during the next 10 years. Among them is the fact that the experiments, especially in high-energy physics, have become more complex. The simpler experiments have been done. The equipment requirements and support facilities and people have increased with the size of the accelerators. In addition, the number of experimental areas has increased, resulting in better utilization of the machines.

New or enlarged areas of research will add to the size of the laboratory. The enrollment in the University of California at Berkeley is expected to increase from 20,000 to 40,000 in the next 10 years. The number of graduate students and postdoctorals who wish to work in, and can contribute to, the work of the laboratory will probably also double.

Physics.—The immediate program in the area of physics is based upon increasing the effectiveness and utilization of the bevatron, 184-inch cyclotron, and related experimental equipment (such as the 72-inch liquid hydrogen bubble chamber) by increasing the experimental and support facilities and by accelerating the development of detection apparatus and data-handling techniques. In the very near future, the electron synchrotron will be closed down and the high-energy program will be concentrated on the major machines. A low-energy program of modest proportions will continue to utilize

the 60-inch cyclotron (and its successor, the 88-inch cyclotron) and the heavy ion linear accelerator.

For the next period of approximately 2 to 5 years, three programs must take place concurrently. These are the continued utilization and improvement of techniques and apparatus, the development of accelerator improvements for the short-range future, and the study of new accelerator possibilities. The accelerator development program, which is contingent on the need and desired characteristics arising from the results achieved with such machines as Brookhaven's Alternating Gradient Synchrotron and CERN, would take a period of 5 to 7 years for development and construction.

Chemistry.—The highly developed synthesis of chemical and physical methods in application to nuclear problems has given this laboratory a unique standing. The 60-inch cyclotron and heavy ion linear accelerator (Hilac) have been used both for making new nuclear species and for studying mechanisms of nuclear reactions. To a lesser extent, the 184-inch cyclotron and bevatron are also being used for experiments in which the radiochemical approach is applicable. The detailed study of radioactive decay properties and static properties of synthesized isotopes and new elements is adding greatly to our knowledge of the structure of nuclei.

The future chemistry program will see an increased use of the accelerators; in particular, a comprehensive program is planned for the 88-inch cyclotron which will replace the 60-inch cyclotron and provide much better facilities for the new directions to which the work is turning. The work on transuranium elements which has always been a major activity will continue to make use of reactors at other sites and is closely geared to the construction of the ultra-high flux reactor at ORNL.

All of the chemistry programs depend on the continuous development of techniques and apparatus as a means of refining and extending the work. New techniques in chemistry, electronic instrumentation, radiation detection, the handling of radioactive materials (with special problems in the transuranium region), cryogenics, and in computer data processing and evaluation are under constant, vigorous development. Increasing applications of these techniques and apparatus are being made to problems far removed from those for which they were originally developed. These practical developments, as well as the basic research findings and training of scientists, constitute a major contribution by this laboratory to the Nation's needs.

Biology and medicine.—In terms of size, this program will remain fairly stable during the next decade, though there will be a number of changes within it.

It is anticipated that greater emphasis will be placed on the use of the particle accelerators available at the laboratory to study the mechanism of cancer induction and control; the hormonal control of diabetes; the nature of irradiation injury to the brain and to map the autonomic and higher functions of the brain. Resultant therapeutic applications will be investigated. Heavy ion studies now being done with the heavy ion linear accelerator (Hilac) are of immediate application to the safety of man's space flight and in studies of extraterrestrial flight. There is the possibility that a particle accelerator specifically designed for medical use may be built.

Biochemical studies concerned with photosynthesis and studies on basic molecular radiation chemistry will continue to provide a major stimulus for many of the ideas essential to an understanding of the effects of radiation on living tissue.

The studies on the distribution of various fission products of heavy elements in the mammal will be redirected to curium and certain new elements of practical importance in the field of radiation hazards. A colony of pathogen-free laboratory animals will be developed for use in analyzing the role of stress from infectious diseases in the acute and chronic radiation syndrome. Other studies, which would expand rapidly if a breakthrough develops, are concerned with the erythropoietic principle obtained from urine which has applications in the radiation syndrome; the newly developed pinhole camera techniques for measuring gamma rays in the whole body or selected areas such as the brain; low background human whole body counting with its applications in the field of medical research and diagnosis; the relation of fatty acids and foods to the radiation syndrome and the relation of the radiation syndrome to disease of the arteries and the aging process; the use of labeled hormones and biological compounds to study biological

processes and diseases. The training effort at the Donner Research Laboratory should expand in a steady, well-controlled fashion.

The role of the Lawrence Radiation Laboratory—Berkeley may also include increased attention and expansion of theoretical and laboratory studies of weapons effects, including fallout.

Inorganic materials.—Within the Chemical Division, there has been a continuing program of modest proportions concerned with the basic physical chemistry of matter, with some emphasis on high-temperature thermodynamics. A proposal from the laboratory for the establishment of a major inorganic materials research program has not been acted on finally by the Commission.

Lawrence Radiation Laboratory—Livermore

Livermore was established in 1950 as a site for the materials testing accelerator (MTA) project being carried on jointly by the Radiation Laboratory and the California Research and Development Corp. In 1952 a branch of the Radiation Laboratory, with the principal function of augmenting nuclear weapons development, was established thre, and the MTA program was concluded in the next few years.

Livermore had approximately 3,600 employees at the end of fiscal year 1959, of whom more than 900 were scientists and engineers. The main function of the Laboratory continues to be the development of new and improved types of nuclear weapons. In the nonweapons area, Livermore is engaged in studies of controlled thermonuclear reactions, high temperature reactors, and peaceful uses of nuclear explosives.

The work on controlled thermonuclear reactions is carried on jointly with the Berkeley Laboratory, where about 20 percent of the work is done currently. Livermore's work in the field involves—

1. Exploration of containment of ionized gases in the mirror arrangement.
2. Exploration of the pinch effect.
3. Construction of equipment leading to the establishment of a circulating layer of electrons with the purpose of containing ionized gases.

The laboratory is also investigating high temperature, air-cooled nuclear reactors with the ultimate purpose of achieving unmanned, nuclear-propelled flight. A part of this work consists of tests on unconventional reactors; these tests take place at the Nevada site. The scope of this project at Livermore encompasses—

1. Theoretical and systems study of a nuclear-propelled ramjet.
2. Materials investigation of possible components of a high-temperature, air-cooled reactor.
3. Assembly of critical masses of model reactors at various temperatures.
4. Running of an air-cooled, full-scale reactor prototype on the ground.

In the last year increasing attention has been paid to the peaceful uses of nuclear explosives. The program—Plowshare—as now visualized includes—

1. Theoretical investigation of possible peaceful uses.
2. Execution of excavation shots aimed at the establishment of harbors and other facilities.
3. Execution of shots aimed at novel methods of oil production.
4. Execution of shots in various media (salt, granite, limestone), aimed at the exploration of special effects and processes.
5. Development of explosives adapted to peaceful uses.

All these activities are supported by a modest program of basic research in nuclear physics and in related subjects.

Lawrence Radiation Laboratory (Livermore), Livermore, Calif.: 8-year trend—Costs, staff, and facilities

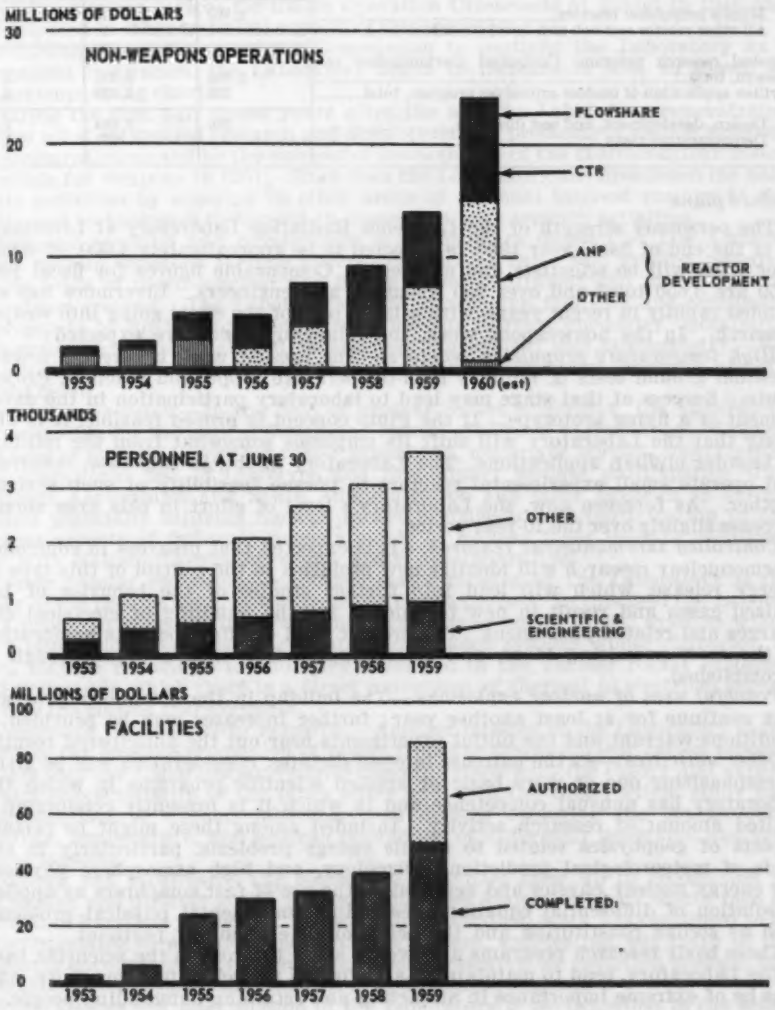
[Dollar amounts are in millions]

	Fiscal year—							
	1960 [1]	1959	1958	1957	1956	1955	1954	1953
Nonweapons research and development costs:[2]								
Reactor development program:								
Missile propulsion	$14.6	$6.9	$2.9	$3.3	$1.5	-------	-------	-------
General reactor research and development	.1	-------	-------	-------	-------	$2.5	$1.5	$1.2
Total reactor development	14.7	6.9	2.9	3.3	1.5	2.5	1.5	1.2
Physical research program: Controlled thermonuclear research	5.5	5.3	5.6	4.1	3.2	2.2	.7	.3
Civilian applications of nuclear explosives (Plowshare)	3.5	1.3	.3	-------	-------	-------	-------	-------
Total nonweapons research and development costs	23.7	13.5	8.8	7.4	4.7	4.7	2.2	1.5
Completed plant and equipment at June 30:[3]								
Accelerators	-------	3.0	4.1	3.9	3.8	.5	.2	-------
Reactors	-------	1.5	.8	.3	.3	.3	.3	-------
Other	-------	45.0	34.4	28.0	25.1	22.7	5.1	1.6
Total	-------	49.5	39.3	32.2	29.2	23.5	5.6	1.6
Personnel at June 30:								
Scientific and engineering	-------	931	885	778	654	535	428	275
Other	-------	2,711	2,141	1,883	1,418	969	611	350
Total employees	-------	3,642	3,026	2,661	2,072	1,504	1,039	625

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $36 million.

LAWRENCE RADIATION LABORATORY(Livermore)

RESEARCH AND DEVELOPMENT



Lawrence Radiation Laboratory, Livermore: Current nonweapons budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$8,795	$13,570	$23,700
Reactor development, total	2,867	6,939	14,700
Missile propulsion reactors	2,867	6,939	14,600
All other reactor research and development			100
Physical research program: Controlled thermonuclear research, total	5,602	5,292	5,500
Civilian application of nuclear explosives program, total	326	1,339	3,500
Design, development, and test direction	326	1,064	2,500
Demonstration tasks		275	1,000

Future plans

The personnel strength of the Lawrence Radiation Laboratory at Livermore, as of the end of fiscal year 1960, is expected to be approximately 4,000, of whom over 1,100 will be scientists and engineers. Comparable figures for fiscal year 1959 are 3,650 total and over 900 scientists and engineers. Livermore has expanded rapidly in recent years, with a large part of the effort going into weapon research. In the nonweapons work, the following trends are expected:

High temperature propulsion reactors.—The present work is directed toward eventual ground tests of military high-temperature propulsion reactors, Project Pluto. Success at that stage may lead to laboratory participation in the development of a flying prototype. If the Pluto concept is proved feasible, it is also likely that the Laboratory will shift its emphasis somewhat from the military to broader civilian applications. The Laboratory might, in this case, construct and operate small experimental reactors to pursue feasibility of such systems further. As foreseen now, the Laboratory's level of effort in this area should increase slightly over the 10-year period.

Controlled thermonuclear research.—It is expected that progress in controlled thermonuclear research will identify new problems in the control of this type of energy release, which will lead into further studies of the behavior of hot ionized gases and result in new techniques for the handling of electrical discharges and related phenomena. The present level of effort permits exploration of the most promising ideas, and seems appropriate until a breakthrough is accomplished.

Peaceful uses of nuclear explosions.—The buildup in the Plowshare program may continue for at least another year; further increases may be provided if conditions warrant and the initial experiments bear out the anticipated results.

Other activities.—As the national interest dictates, consideration will be given to emphasizing one or more basic or applied scientific programs in which the Laboratory has unusual competence and in which it is presently conducting a limited amount of research activity. Included among these might be certain aspects of geophysics related to atomic energy problems, particularly in the fields of meteorological prediction, seismology, and high atmosphere physics; low energy nuclear physics and neutronics; the use of fast computers as applied to solution of differential equations describing fundamental physical problems such as stellar constitution and the behavior of elementary particles.

These basic research programs also would serve to broaden the scientific base of the Laboratory, tend to maintain its standing in the scientific community, and thus be of extreme importance in attracting and retaining outstanding people.

Los Alamos Scientific Laboratory

The Los Alamos Scientific Laboratory was established under a contract with the University of California in the early part of 1943 to provide a focal point for the previously diversified research directed toward the feasibility of an atomic bomb. Its initial staffing was partly military and partly civilian, although the major technical direction was primarily the latter. It attained its

wartime peak strength during the summer of 1945 with about 1,500 civilians and 2,000 military personnel more or less directly involved in Laboratory activities.

The Laboratory conducted the first nuclear weapons test at Alamogordo on July 16, 1945, and provided the actual weapons and the technical crews associated with them for the bomb drops the following month.

By the time of the adoption of the Atomic Energy Act of 1946, the technical military staff of the Laboratory had essentially vanished and the civilian staff had decreased to about 1,300. Nevertheless, the Laboratory successfully provided the nuclear devices for use in Operation Crossroads at Bikini in 1946 and participated in other technical aspects of this operation.

Following the decision by the Commission to continue the Laboratory as a permanent institution, the Laboratory began to increase in size, as shown on the accompanying chart.

During the first half dozen years after the war the Laboratory concentrated almost all of its applied research and development on problems of atomic weapons development, climaxed by the successful development of the thermonuclear fusion principle for weapons in 1951. Since then the Laboratory has broadened the base of its activities by applying to other areas of national interest various of the skills and technologies developed in connection with weapon activities.

Weapons research and development is the primary mission at Los Alamos; other current missions include general conduct of basic and applied research in the fields of thermonuclear and fission power programs; and nuclear rocket propulsion systems. The Laboratory contains research facilities and equipment appropriate to fundamental research in nuclear physics, chemistry, metallurgy and cryogenics; computational techniques; biophysics; and biochemistry. Research is conducted in all these fields. The major nonweapons programs are discussed below.

Rocket propulsion.—In the field of nuclear rocket propulsion, the Laboratory is responsible for theoretical design and system studies of various types of potential uses of nuclear energy for rocket propulsion, materials, studies, construction, and operational test of prototype and preliminary models, participation with National Aeronautics and Space Administration and other agencies in system studies potenially utilizing nuclear rocket propulsion, and participation in the nuclear aspects of full-scale nuclear motor of nuclear flight tests in collaboration with National Aeronautics and Space Administration.

Power reactor technology.—Another major mission of the Laboratory is the study of the production of power from the fission process. In this field the Laboratory primarily concerns itself with homogeneous or mobile fuels; systems which burn plutonium; very high temperature gas cooled systems whose character, in part, may be related to technologies developed in the nuclear rocket systems; and systems in which there is a direct conversion of thermal to electrical energy such as the plasma thermocouple.

Controlled thermonuclear research.—Another mission of the Laboratory is the study of the possible production of power from the thermonuclear fusion process. In this field the Laboratory primarily concerns itself with the theory and experimental characteristics of the pinch effect and with the construction, study and understanding of various laboratory-size devices exploring the containment, stability, temperature, and neutron production of differently generated and contained plasmas.

Biology and medicine.—The biomedical activities grew up in recognition of the unique and difficult health problems that Los Alamos workers would face as a result of handling plutonium. Most of the biomedical work has continued to be directly related to weapons research, development, and testing, but many of the problems encountered have necessitated basic research on radiation biology, biochemistry, biophysics, radiochemistry, and instrumentation.

Basic studies.—A final mission of the Laboratory is participation in the scientific life of the United States through basic research and its publication in those areas which are peripheral to and stimulate the more specifically programmatic missionsof the Laboratory, and through cooperation with educational and industrial research institutions.

Los Alamos Scientific Laboratory, Los Alamos, N. Mex.: 10-year trend—Costs, staff, and facilities

[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Nonweapons research and development costs:[2]										
Reactor development program:										
Missile propulsion	$15.8	$12.1	$7.9	$5.9	$2.8	------	------	------	------	------
General reactor research and development	5.5	3.3	3.0	2.2	1.6	------	------	------	------	------
Total reactor development	21.3	15.4	10.9	8.1	4.4	------	------	------	------	------
Physical research program: Controlled thermonuclear research	3.3	3.0	2.3	1.8	1.1	$1.0	$0.3	$0.1	$0.1	$0.1
Biology and medicine program: Biomedical problems in atomic energy operations	1.0	1.0	.9	.9	.8	.7	.7	.7	.6	.7
Total nonweapons research and development	25.6	19.4	14.1	10.8	6.3	1.7	1.0	.8	.7	.8
Completed plant and equipment at June 30:[3]										
Accelerators	------	2.0	2.0	2.0	2.0	------	------	------	------	------
Reactors	------	.6	.6	.6	.6	------	------	------	------	------
Other	------	138.0	125.2	120.4	119.4	117.4	119.9	95.3	63.4	49.4
Total	------	140.6	127.8	123.0	122.0	117.4	119.9	95.3	63.4	49.4
Personnel at June 30:										
Scientific and engineering	------	979	934	857	778	725	679	602	529	464
Other	------	2,322	2,301	2,320	2,218	2,220	2,317	2,290	2,233	2,176
Total employees (see note below)	------	3,301	3,235	3,177	2,996	2,945	2,996	2,892	2,762	2,640

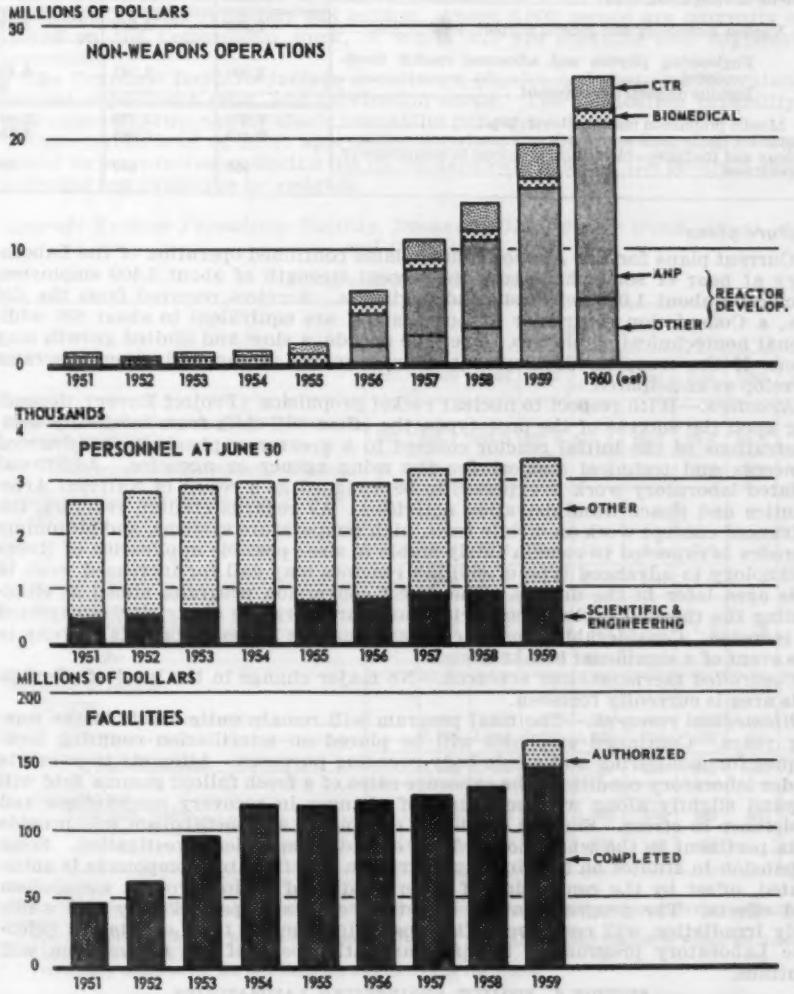
[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $22,800,000.

NOTE RE PERSONNEL.—Los Alamos Scientific Laboratory receives operational and maintenance services from the Zia Co. To place Los Alamos employment figures on a basis more nearly comparable with the other laboratories, the following tabulation of Los Alamos employment includes an appropriate allocation of Zia Co. personnel.

	1959	1958	1957	1956	1955	1954	1953	1952	1951
Personnel at June 30:									
Scientific and engineering	979	934	857	778	725	679	602	529	464
Other	3,094	3,127	3,138	3,068	3,002	3,231	3,210	3,210	2,731
Total employees	4,073	4,061	3,995	3,846	3,727	3,910	3,812	3,739	3,195

LOS ALAMOS SCIENTIFIC LABORATORY

RESEARCH AND DEVELOPMENT



Los Alamos Scientific Laboratory: Current nonweapons budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$14,158	$19,368	$25,611
Reactor development, total	10,868	15,420	21,270
Nuclear technology and general support, total	2,999	3,242	5,470
Engineering physics and advanced reactor development	2,999	3,242	5,450
Residue disposal development			20
Missile propulsion reactor, Rover, total	7,869	12,178	15,800
Controlled thermonuclear research	2,355	2,989	3,350
Biology and medicine—biomedical problems in atomic energy operations	935	959	991

Future plans

Current plans for Los Alamos contemplates continued operation of the Laboratory at near or somewhat above its present strength of about 3,400 employees, including about 1,000 scientists and engineers. Services received from the Zia Co., a Commission contractor at Los Alamos, are equivalent to about 800 additional nontechnical employees. Over the decade, a slow and limited growth may occur if the weapons development effort remains strong and other programs develop as anticipated.

Reactors.—With respect to nuclear rocket propulsion (Project Rover), depending upon the success of the prototypes, the effort will shift from feasibility demonstrations of the initial reactor concept to a greater emphasis upon advanced concepts and technical support for the using agency or agencies. Additional related laboratory work is expected to be assigned as a result of National Areonautics and Space Administration activities. As regards civilian reactors, the advanced concept work on mobile fuels, high temperature systems, and plutonium burners is expected to remain fairly stable in size; possible application of Rover technology to advanced type of civilian reactors may call for increased work in this area later in the decade. The direct conversion program, aimed at eliminating the thermal cycle in converting nuclear energy to electricity, is expected to increase. Considerably greater emphasis may be placed upon this activity in the event of a significant breakthrough.

Controlled thermonuclear research.—No major change in the level of effort in this area is currently foreseen.

Biomedical research.—The total program will remain quite stable in the coming years. Continued emphasis will be placed on scintillation counting techniques for monitoring and whole body counting purposes. Attempts to re-create under laboratory conditions the exposure rates of a fresh fallout gamma field will expand slightly along with measures of changes in recovery mechanisms and resistance to stress. Smaller studies in cell injury and metabolism will provide data pertinent to the whole body effects of radiation under investigation. Some expansion in studies on the toxicity of tritium and tritiated compounds is anticipated, offset by the completion of other studies of fission product metabolism and effects. The program on the long term effects of partial body and whole body irradiation will continue. The close adherence of the Los Alamos Scientific Laboratory program to the programmatic needs of the Commission will continue.

SECTION 6. PROJECT ENGINEERING LABORATORIES

Aircraft Nuclear Propulsion Facility—Evendale

Performance of research and development work on aircraft nuclear propulsion by the General Electric Co. has been supported jointly by the Air Force and the Commission since 1951. The project as a whole is aimed at the development of a direct cycle, nuclear propelled, aircraft engine.

The Air Force is responsible for the propulsion machinery, other than the reactor itself, and the Commission sponsors the work on the reactor.

The major problems toward which the work is directed include the development of fuel elements and structural material capable of withstanding the high temperatures which must be reached in order to achieve the necessary performance, and the shield problems which result from the weight limitations within which the machine must be designed. Facilities for testing reactors developed at Evendale have been constructed at the National Reactor Testing Station in Idaho, where a substantial supporting facility is operated by the General Electric Co. as a part of its Commission contract.

The facilities at Evandale used in the Commission work represent an Air Force investment of approximately $38 million. About 3,000 people are currently employed on the Commission work, of whom 625 are scientific and engineering personnel.

The Evandale facilities include metallurgy, physics and chemical laboratories, critical experiment cells, and fabrication shops. The fabrication capability is approximately two reactor-shield assemblies per year.

The current level of effort appears appropriate for the next few years. There would be some increases during the major hardware phase of the program should a ground test prototype be assigned.

Aircraft Nuclear Propulsion Facility, Evendale, Ohio: 9-year trend—Costs, staff, and facilities

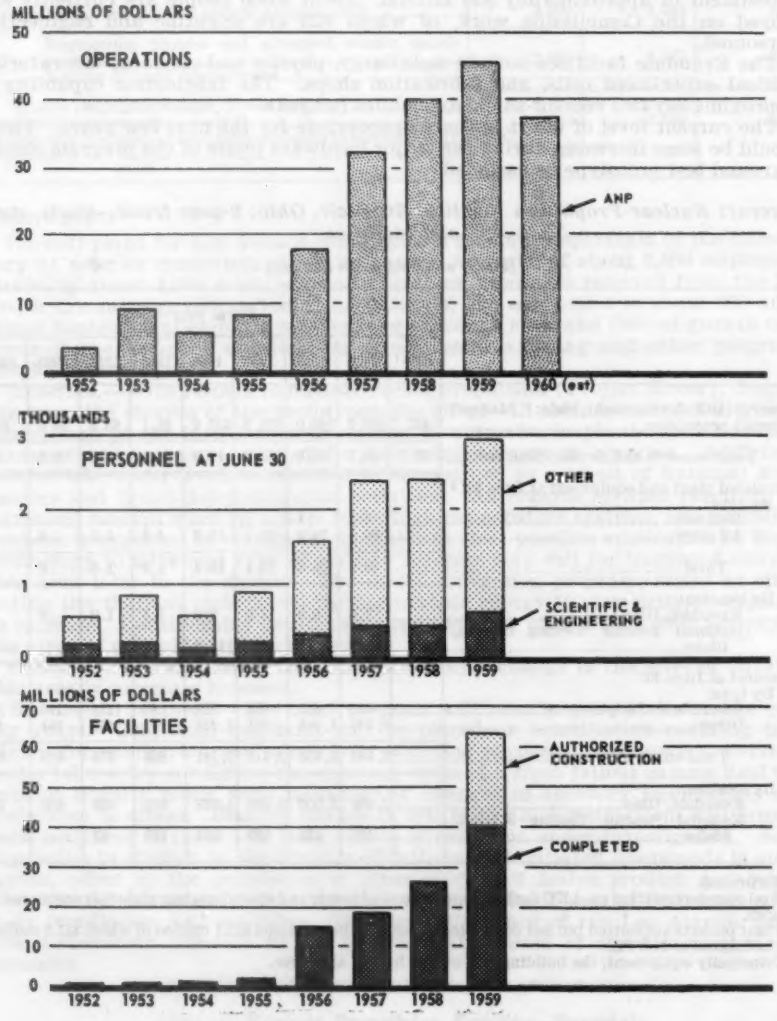
[Dollar amounts are in millions]

	Fiscal year—								
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952
Research and development costs:[2] Manned aircraft propulsion	$37.7	$45.7	$40.0	$32.2	$17.9	$8.1	$5.8	$9.6	$3.5
Total research and development costs	37.7	45.7	40.0	32.2	17.9	8.1	5.8	9.6	3.5
Completed plant and equipment at June 30:[3]									
By type:									
Reactors		1.5	.1						
All other		39.4	28.2	19.1	15.3	1.5	1.0	.6	.1
Total		40.9	28.3	19.1	15.3	1.5	1.0	.6	.1
By location:									
Evendale, Ohio[4]		7.6	5.9	3.6	2.0	1.5	1.0	.6	.1
National Reactor Testing Station, Idaho		33.3	22.4	15.5	13.3				
Personnel at June 30:									
By type:									
Scientific and engineering		625	487	435	328	187	127	179	156
Other		2,356	1,948	1,981	1,233	701	451	681	420
Total employees		2,981	2,435	2,416	1,561	888	578	860	576
By location:									
Evendale, Ohio		2,490	2,000	2,006	1,228	695	535	860	576
National Reactor Testing Station, Idaho		491	435	410	333	193	43		

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $23.1 million of which $21.9 million is to be located at NRTS.
[4] Principally equipment; the buildings are owned by the Air Force.

AIRCRAFT NUCLEAR PROPULSION FACILITY-EVENDALE

RESEARCH AND DEVELOPMENT



Aircraft Nuclear Propulsion Facility—Evendale: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$39,961	$45,681	$37,732
Reactor development, aircraft: Propulsion direct cycle, total	39,961	45,681	37,732
Research and development		34,998	31,462
Fuel fabrication		2,548	1,240
Operations		1,752	1,900
Reactor experiment fabrication		6,383	3,130

Bettis Laboratory

The execution of a contract between the Commission and the Westinghouse Electric Corp. on December 29, 1948, for the development of a nuclear propulsion plant for submarine application marks the origin of the Bettis Laboratory. Bettis is wholly owned by the Government and is operated for the Commission by the Westinghouse Electric Corp.

The submarine thermal reactor was the first large-scale development project assigned to Bettis. This project resulted in the development, construction, and test of the land prototype of the water-cooled reactor plant for the U.S.S. *Nautilus*, followed by installation of the first submarine reactor plant in the *Nautilus* itself. The prototype was constructed at the National Reactor Testing Station; power operations began in May 1953. The *Nautilus* went to sea in January 1955.

In order to exploit quickly the *Nautilus* development and Bettis experience in the field of water reactor technology, the Commission assigned to the Bettis Laboratory the responsibility for the development of the U.S.S. *Skate* type of submarine nuclear propulsion plant; the development of the pressurized water reactor plant for the Nation's first full-scale central station atomic powerplant at Shippingport, Pa.; the development of the nuclear propulsion plant for use in single screw, high speed, attack, and Polaris missile launching submarines; and the development, construction, operation, and test, at the National Reactor Testing Station, of a prototype nuclear propulsion plant for application to large naval surface ships such as aircraft carriers and guided missile cruisers.

Bettis Laboratory has about 600,000 square feet of engineering offices, laboratories, fuel fabrication and test facilities, and shop space, and leases an additional 300,000 square feet of offices and laboratory space in the Pittsburgh area.

Bettis Laboratory, Pittsburgh, Pa.: 10-year trend—Costs, staff, and facilities

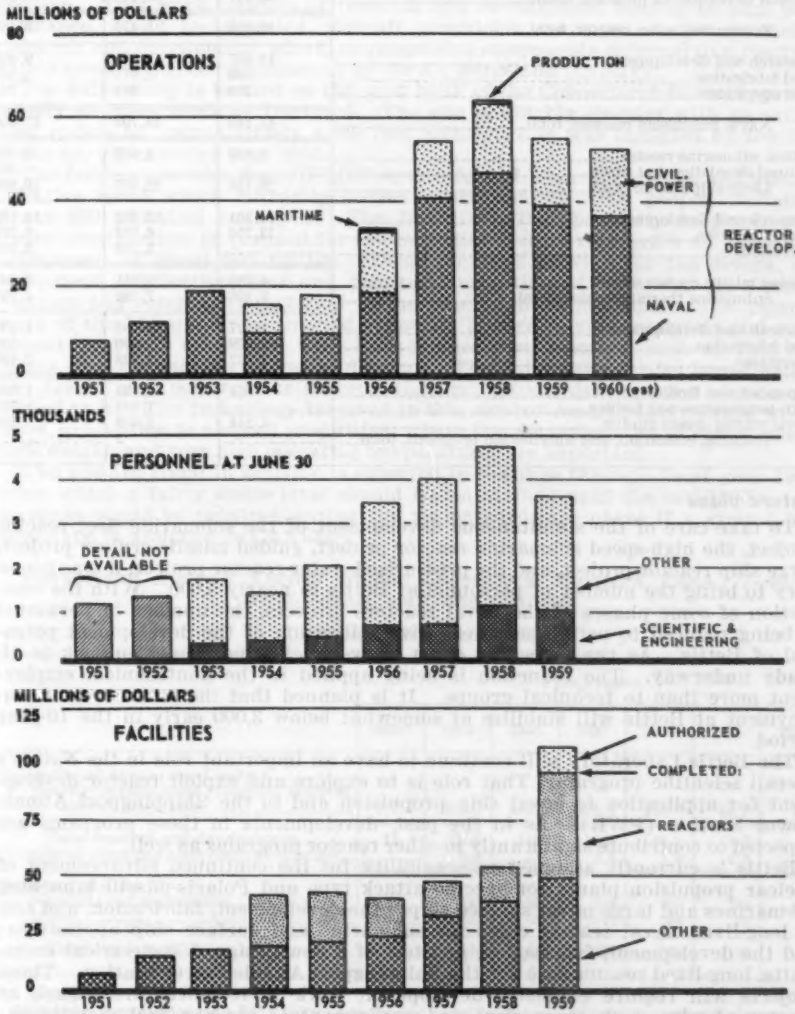
[Dollar amounts are in millions]

	Fiscal year—									
	1960 [1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs: [2]										
Production program	------	------	$0.1	------	------	------	------	------	------	------
Reactor development program:										
Civilian power reactors	$16.2	$15.5	16.7	$14.4	$14.6	$10.0	$7.2	------	------	------
Merchant ship	------	------	------	------	.1	------	------	------	------	------
Naval propulsion	37.1	39.7	47.2	40.9	18.8	8.4	8.4	$19.3	$11.9	$7.1
Total, reactor development	53.3	55.2	63.9	55.3	33.5	18.4	15.6	19.3	11.9	7.1
Total, research and development	53.3	55.2	64.0	55.3	33.5	18.4	15.6	19.3	11.9	7.1
Personnel at June 30:										
By types:										
Scientific and engineering	------	1,036	1,109	824	752	468	376	331	[3]	------
Other	------	2,591	3,630	3,197	2,749	1,541	1,117	1,438	------	------
Total employees	------	3,627	4,739	4,021	3,501	2,009	1,493	1,769	1,366	1,180
By location:										
Pittsburgh, Pa	------	2,917	3,940	3,472	3,080	1,698	1,254	1,524	1,366	1,180
National Reactor Testing Station, Idaho	------	710	799	549	421	311	239	245	------	------
Completed plant and equipment at June 30: [4]										
By type:										
Reactors	------	$46.6	$17.2	$16.3	$15.8	$22.2	$22.2	------	------	------
All other	------	48.9	35.5	31.0	23.0	20.1	17.9	$16.9	$14.4	$6.2
Total	------	95.5	52.7	47.3	38.8	42.3	40.1	16.9	14.4	6.2
By locations:										
Pittsburgh, Pa	------	39.7	36.0	31.8	23.6	20.9	19.1	16.9	14.4	6.2
National Reactor Testing Station, Idaho	------	55.8	16.7	15.5	15.2	21.4	21.0	------	------	------

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available in this and prior years.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $12.4. Of this amount, $9.7 will be located at Pittsburgh and $2.7 at NRTS.

BETTIS LABORATORY

RESEARCH AND DEVELOPMENT



Bettis Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$64,022	$55,202	$53,275
Production process development, total	75	15	
Reactor development program, total	63,947	55,185	53,275
Pressurized water reactor, total	16,698	15,476	16,185
Research and development	15,847	12,837	9,910
Fuel fabrication	596	1,975	5,540
Test operations	255	664	735
Naval propulsion reactors, total	47,249	39,709	37,090
Attack submarine reactor	5,059	2,907	6,410
Natural circulation test plant			500
Large ship reactor, total	28,116	22,955	19,980
Research and development	14,361	12,252	14,170
Fuel fabrication	13,755	6,973	2,275
Operations		3,730	3,535
Guided missile cruiser reactor	4,338	2,811	2,200
Submarine thermal reactor, total	7,828	7,292	4,290
Research and development	1,527	4,065	1,400
Fuel fabrication	2,879	599	400
Operations	3,422	2,628	2,490
Expanded core facility	664	1,138	1,310
High-temperature test facility		1,148	1,700
Naval reactor design studies	1,244	1,458	700
Training, education, and information programs, total		2	

Future plans

To take care of the simultaneous development of the submarine fleet reactor project, the high-speed submarine reactor project, guided missile cruiser project, large ship reactor project, and the pressurized water reactor project, it was necessary to bring the number of personnel at Bettis to nearly 5,000. With the completion of some phases of the naval reactors projects, the number of personnel is being reduced to permit more effective utilization of the development potential of Bettis. As the preceding chart shows, such a personnel cutback is already underway. The reduction is being applied to the nontechnical employment more than to technical groups. It is planned that the total level of employment at Bettis will stabilize at somewhat below 3,000 early in the 10-year period.

The Bettis Laboratory will continue to have an important role in the Nation's overall scientific program. That role is to explore and exploit reactor development for application to naval ship propulsion and to the Shippingport Atomic Power Station (PWR). As in the past, developments in these programs are expected to contribute significantly to other reactor programs as well.

Bettis is currently assigned responsibility for the continued advancement of nuclear propulsion plants for specific attack type and Polaris-missile-launching submarines and large naval surface ships; the development, fabrication, and test of long-lived naval reactor cores for submarine and surface ship application; and the development, fabrication, and test of a new design, 150 electrical megawatts, long-lived reactor core for the Shippingport Atomic Power Station. These projects will require extensive development work in technical areas such as reactor physics, both theoretical and experimental; nuclear fuel metallurgy; heat transfer, reactor core instrumentation; and advanced fuel fabrication techniques.

Nuclear reactor plants and reactor cores of the types developed by the Bettis Laboratory will continue to be procured from private industry on a fixed price basis.

Connecticut Aircraft Nuclear Engine Laboratory (CANEL)

Work on aircraft nuclear propulsion at the Pratt & Whitney Aircraft Division of United Aircraft Corp. started under Commission contract in May 1953. The work is now conducted at the Connecticut Aircraft Nuclear Engine Laboratory, or CANEL, an Air Force-owned facility, specifically designed for the development of an indirect cycle nuclear powerplant for aircraft propulsion. The facility is operated by Pratt & Whitney, under contract with the Air Force. The major program at CANEL at the present time is being sponsored by the Commission. This work consists of research and development leading to high performance, liquid metal-cooled, aircraft propulsion reactors. A less extensive research and development effort, on propulsion components external to a reactor-shield assembly, is being sponsored by the Air Force and the Navy.

The Laboratory is located on the west bank of the Connecticut River, approximately 18 miles south of Hartford. The site is roughly circular with an exclusion radius of approximately 4,000 feet. Construction was initiated by the Air Force during calendar year 1955.

The facility provides about 680,000 square feet of laboratory, shop, and administrative space which currently houses approximately 1,600 people, including about 400 technical employees. The facilities either presently in place, now under construction, or planned for the immediate future represents an Air Force investment of about $60 million. These facilities provide for the design, development, fabrication, test and post-test inspection of experimental aircraft reactors and components external to the reactor-shield assembly. The present work of the Laboratory is directed primarily toward solving materials and component problems associated with high temperature reactors, such as fuel elements, heat exchangers, valves, and pumps. The Laboratory is also investigating the design of a new reactor concept, the first project development mission assigned to it. The technology involved in this reactor concept may have applications, in addition to aircraft propulsion, where the characteristics of compactness, lightweight, and very high operating temperatures are important.

The upward trend in activity is expected to continue through fiscal year 1961, after which a fairly stable level should be maintained until the mid-1960's. An increase would be required during the major hardware phase if a ground test prototype is assigned to CANEL.

Connecticut Aircraft Nuclear Engine Laboratory, Hartford, Conn.: 7-year trend—Costs, staff, and facilities

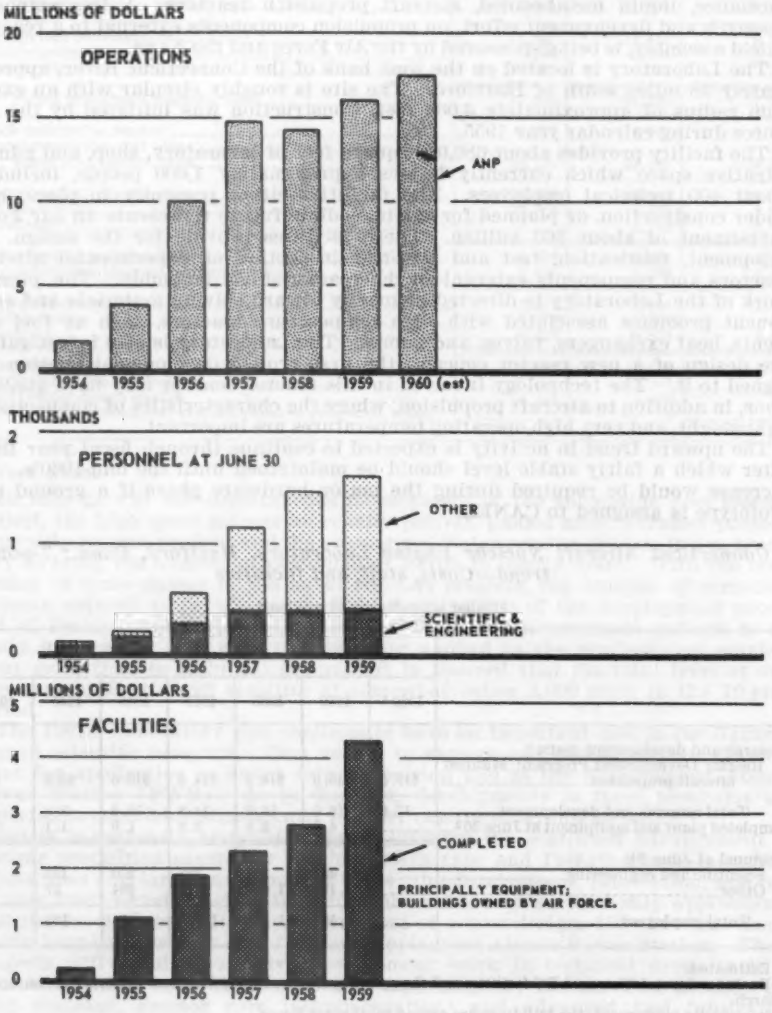
[Dollar amounts are in millions]

	Fiscal year—						
	1960 [1]	1959	1958	1957	1956	1955	1954
Research and development costs: [2]							
Reactor Development Program: Manned aircraft propulsion	$17.5	$16.0	$14.2	$14.8	$10.0	$3.8	$1.6
Total research and development	17.5	16.0	14.2	14.8	10.0	3.8	1.6
Completed plant and equipment at June 30 [3]	------	4.3	2.8	2.3	1.9	1.1	.2
Personnel at June 30:							
Scientific and engineering	------	401	391	388	270	135	62
Other	------	1,193	1,067	741	264	57	13
Total employees	------	1,594	1,458	1,129	534	192	75

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Principally equipment; the buildings are owned by the Air Force.

CONNECTICUT AIRCRAFT NUCLEAR ENGINE LABORATORY

RESEARCH AND DEVELOPMENT



Connecticut Aircraft Nuclear Engine Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$14,186	$15,977	$17,500
Reactor development—Aircraft propulsion indirect cycle—Total	14,186	15,977	17,500
Low power reactor experiment			9,700
Advanced research and development	14,186	15,977	7,800

Knolls Atomic Power Laboratory

The Knolls Atomic Power Laboratory had its inception in 1946 when the Commission signed a contract with the General Electric Co. for the operation of a laboratory for research and development in atomic energy.

The principal project during the early history of the laboratory was the sodium-cooled breeder reactor. Supporting work for Hanford also was carried on. When work on the sodium breeder reactor stopped, the effort of the laboratory was reoriented to the submarine intermediate reactor project. This was the first large-scale development effort for naval application to be undertaken at the Knolls Atomic Power Laboratory. Knolls developed, constructed, and tested the land prototype of the sodium-cooled reactor for the U.S.S. *Seawolf*. This prototype was constructed at West Milton, N.Y.; it achieved criticality in March 1955, and was operated for test and evaluation until it was shut down in February 1957. The sodium reactor plant installed in the U.S.S. *Seawolf* achieved criticality in June 1956. This plant operated for 2 years, during which the ship steamed over 71,000 miles. However, the submarine intermediate reactor project was discontinued because sodium proved less suitable than pressurized water as a coolant for naval reactors, and the *Seawolf's* reactor is now being replaced by a water-cooled reactor plant similar to that of the U.S.S. *Nautilus*.

Knolls is currently assigned three major reactor development projects for naval application; the submarine advanced reactor project, the destroyer reactor project, and, most recently, a natural circulation pressurized water plant for submarine application. The submarine advanced reactor project encompasses the design, construction, development and test of a two-reactor pressurized water nuclear propulsion plant for the radar picket submarine *Triton*. A land prototype of one reactor of this plant was constructed at West Milton, N.Y., and is now undergoing test and evaluation. The *Triton* itself commenced sea trials in September 1959. The destroyer reactor project was assigned to Knolls in fiscal year 1957. This project covers the development of a pressurized water nuclear propulsion plant for installation in a large destroyer-type naval ship. Because of the developmental nature of this plant a land prototype is being constructed at West Milton, N.Y. in the 225-foot diameter sphere which previously housed the land prototype of the *Seawolf* sodium-cooled propulsion plant.

The Knolls Atomic Power Laboratory has about 580,000 square feet of engineering office, laboratories, and shop space and employs about 2,200 people, a little less than 700 of whom are engineers and scientists.

The size of the staff at Knolls is expected to remain at about this level.

Knolls Atomic Power Laboratory, Schenectady, N.Y.: 10-year trend—Costs, staff, and facilities

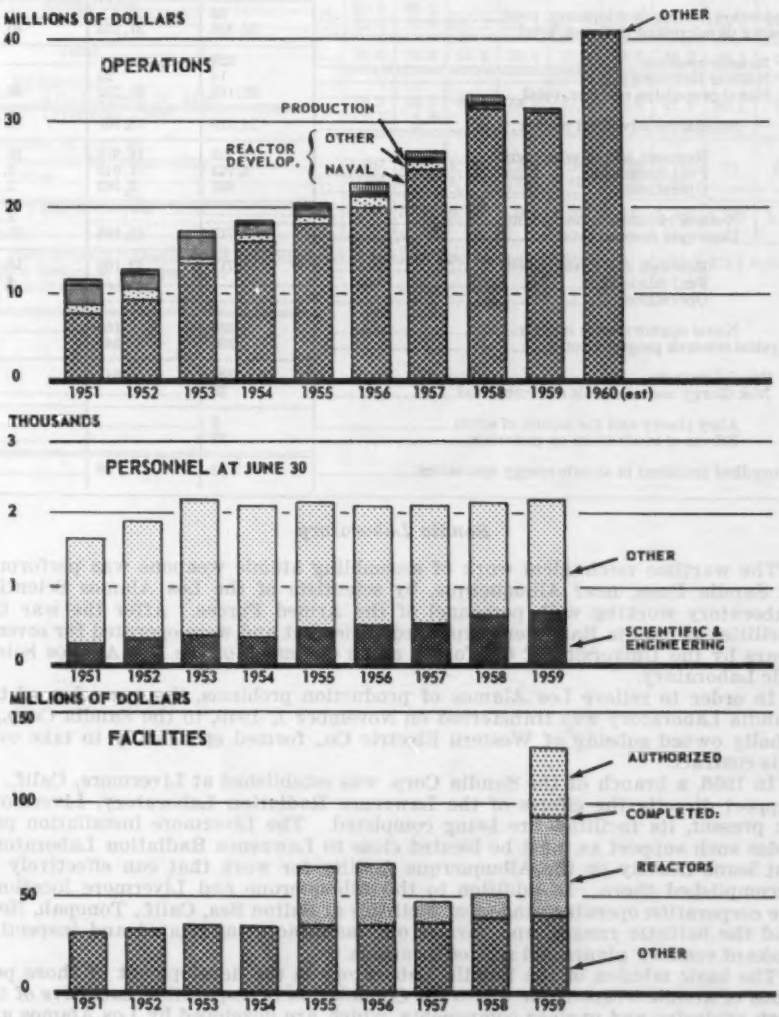
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	------	------	$0.1	$0.3	$0.5	$0.9	$1.4	$2.6	$2.7	$2.8
Reactor development program:										
Naval propulsion	$40.3	$31.3	32.2	24.2	20.0	18.1	16.0	13.4	9.3	7.7
General reactor research and development	------	------	.3	1.3	1.1	1.1	1.1	.8	1.1	.8
Total, reactor development	40.3	31.3	32.5	25.5	21.1	19.2	17.1	14.2	10.4	8.5
Physical research program	.5	.3	.4	.8	.9	.3	.1	------	------	.2
Other	------	.1	.1	.1	.1	.1	.1	.4	.1	------
Total research and development costs	40.8	31.7	33.1	26.7	22.6	20.5	18.7	17.2	13.2	11.5
Completed plant and equipment at June 30:[3]										
Reactors	------	34.7	12.2	11.3	32.4	30.7	------	------	------	------
Other	------	38.7	38.1	35.1	34.1	34.4	34.1	33.4	32.0	30.5
Total	------	73.4	50.3	46.4	66.5	65.1	34.1	33.4	32.0	30.5
Personnel at June 30:										
Scientific and engineering	------	670	606	484	473	440	353	375	307	238
Other	------	1,508	1,553	1,633	1,670	1,757	1,717	1,802	1,610	1,408
Total employees	------	2,178	2,159	2,117	2,143	2,197	2,070	2,177	1,917	1,646

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $56.5 million.

KNOLLS ATOMIC POWER LABORATORY

RESEARCH AND DEVELOPMENT



Knolls Atomic Power Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$33,068	$31,655	$40,746
Production process development, total	65		
Reactor development program, total	32,526	31,255	40,293
Reactor systems	329		
Nuclear technology	14	23	13
Naval propulsion reactors, total	32,183	31,232	40,280
Submarine advanced reactor, total	24,216	18,901	16,075
Research and development	17,503	14,915	10,790
Fuel fabrication	5,792	1,043	2,785
Operations	921	2,943	2,500
Natural circulation test plant			3,200
Destroyer reactor, total	7,717	12,166	21,005
Research and development	7,717	12,166	15,520
Fuel fabrication			4,985
Operations			500
Naval reactor design studies	250	165	
Physical research program, total	395	341	453
Special projects	365	341	453
Metallurgy and materials research, total	30		
Alloy theory and the nature of solids	8		
Effects of irradiations on materials	22		
Biomedical problems in atomic energy operations	82	59	

Sandia Laboratory

The wartime mechanical work of assembling atomic weapons was performed at Sandia Base, near Albuquerque, by scientists of the Los Alamos Scientific Laboratory working with personnel of the Armed Forces. After the war the facilities at Sandia Base were expanded somewhat and were operated for several years by the University of California as an extension of the Los Alamos Scientific Laboratory.

In order to relieve Los Alamos of production problems, the operation of the Sandia Laboratory was transferred on November 1, 1949, to the Sandia Corp., a wholly owned subsidy of Western Electric Co., formed specifically to take over this contract.

In 1956, a branch of the Sandia Corp. was established at Livermore, Calif., to support directly the efforts of the Lawrence Radiation Laboratory, Livermore. At present, its facilities are being completed. The Livermore installation provides such support as must be located close to Lawrence Radiation Laboratory, but leans heavily on the Albuquerque facility for work that can effectively be accomplished there. In addition to the Albuquerque and Livermore locations, the corporation operates range-test facilities at Salton Sea, Calif., Tonopah, Nev., and the ballistic ranges, and carries out manufacturing-related and inspection tasks of vendors' plants and related locations.

The basic mission of the Sandia Laboratory is the development of those portions of atomic weapons for which the Commission is responsible, exclusive of the high explosive and nuclear components, which are developed by Los Alamos and Livermore.

In the exercise of this development responsibility, Sandia Laboratory also conducts component development, quality control, reliability engineering, tool and test equipment development, military liaison, and manufacturing relations. A program of basic and applied research is conducted in fields related to the Sandia Laboratory development task.

Sandia Laboratory, Albuquerque, N. Mex.: Trend of staff and facilities

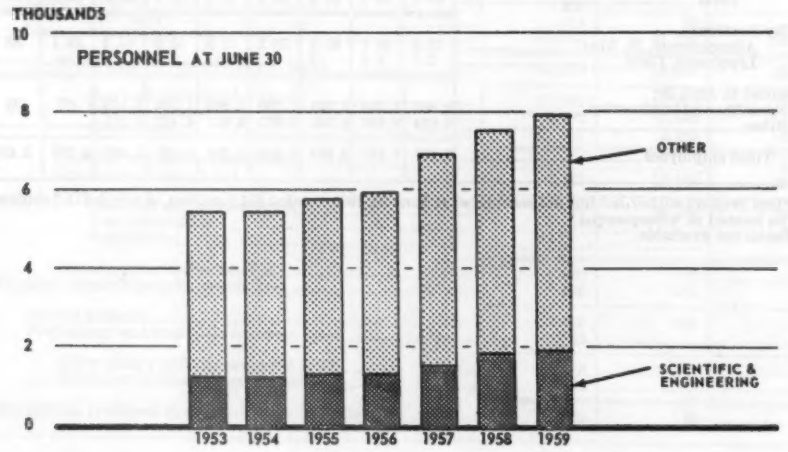
[Dollar amounts are in millions]

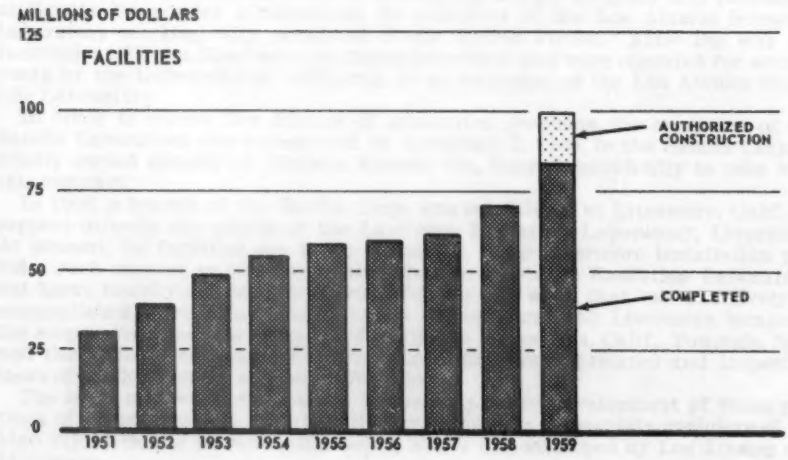
	Fiscal year—								
	1959	1958	1957	1956	1955	1954	1953	1952	1951
Completed plant and equipment at June 30: [1]									
By type:									
Accelerators	$0.2	$0.2							
All other	82.8	70.0	$61.3	$59.2	$57.0	$53.8	$47.2	$39.1	$30.8
Total	83.0	70.2	61.3	59.2	57.0	53.8	47.2	39.1	30.8
By location:									
Albuquerque, N. Mex	75.3	68.7	61.1	59.2	57.0	53.8	47.2	39.1	30.8
Livermore, Calif	7.7	1.5	.2						
Personnel at June 30:									
Scientific and engineering	1,907	1,753	1,521	1,296	1,289	1,258	1,155	[2]	[2]
Other	6,034	5,698	5,361	4,613	4,417	4,162	4,251		
Total employees	7,491	7,451	6,882	5,909	5,706	5,420	5,406	4,775	3,418

[1] Plant projects authorized but not completed at June 30, 1959, totaled $16.5 million, of which $15.7 million will be located at Albuquerque.
[2] Detail not available.

SANDIA LABORATORY
RESEARCH AND DEVELOPMENT

(INCLUDING PERSONNEL AND FACILITIES USED IN PRODUCTION ACTIVITIES)





Future plans

Current planning for the Sandia Corp. as a whole envisions a personnel strength remaining at about 8,000 individuals (2,000 professionally trained scientists and engineers) for early future years. Following that, employment levels necessarily will depend in large part upon the required scope of weapons work and the programs other than weapons development that the laboratory will be called upon to undertake.

With time, and if Sandia's weapon load permits, activities other than weapons development, such as the following, will be initiated or increased within the technical capacity and facilities available:

1. Increased effort in applied research and exploratory development to provide better components, materials, and non-nuclear systems.
2. Study of environmental effects on a nuclear warhead.
3. Development of instrumentation for detecting nuclear explosions.
4. Conduct of studies in cratering phenomena and containment of radioactive products, and product engineering for Project Plowshare.

SECTION 7. PRODUCTION PLANT LABORATORIES

Introduction

Laboratory facilities have been provided at the Commission's production plant sites to provide technical support to the production operations. The work of these laboratories is aimed primarily at improving processing methods or plant productivity to enable requirements to be met with maximum economy and safety. They also provide the capability for the development of processes or techniques needed to meet new requirements as they may arise. In general, the level of effort in support of the production program is directly related to the achievement of production objectives. The level has increased as the scope of the production operation has increased.

The laboratory facilities at Hanford and Savannah River are alone among the Commission laboratories discussed in this report in that their primary mission has been, and will continue to be, the technical support of the production operation. However, following completion of the major expansion efforts and the solution or near solution of many critical problems related to obtaining maximum productivity from the installed plant, the level of production support required of these laboratories can be somewhat reduced. At the same time, other areas of the Commission's research and development programs have developed a need for increased effort in areas of technology where Hanford and Savannah River, by reason of their facilities, and particularly by the experience of their personnel, can make significant contributions. Accordingly, assignments have been made to these laboratories which provide them with important missions in nonproduction activities.

The assignment of nonproduction missions to these laboratories has been beneficial to the Commission program in several ways. The specialized nature of many of the facilities at Hanford and Savannah River are nowhere duplicated in other installations. The technical background and experience of personnel at Hanford and Savannah River resulting from their intimate association with the production program has provided a valuable source of technical capability in these specific areas. Finally, it has provided new technical horizons for a substantial number of the scientific personnel. The problem of retention of adequate scientific talent at the production sites to be drawn on in the event of a critical operational problem in the production facilities has in this way been minimized.

A similar pattern will be followed in the future in assigning nonproduction missions to the Hanford and Savannah River laboratories, where benefits to the Commission program, both technical and economic, will result.

Hanford Laboratory

During the approximately 15 years of operation of the Hanford complex, laboratory, semiworks, and support facilities valued at more than $45 million have been installed at that site; additional facilities are now under construction, at a cost of about $25 million. Since Hanford was the first major reactor site, the research and development program to support the production activities was established on a relatively broad base, encompassing not only reactor design and operation, but also the study of nuclear and chemical safety, plutonium and uranium metallurgy, chemical separations technology, waste disposal, and environmental effects. These activities are carried on by the General Electric Co., operator of the entire Hanford complex.

The environmental biology program originated with the need to insure an adequate radiation protection program, and to determine the possible effects of the reactor cooling water on aquatic life in the Columbia River. In recent years, the character of this research program has gradually changed towards a more basic approach to the problems being studied. In addition, a closer liaison between the northwestern universities and Hanford is developing which promises to be beneficial both to the university community and to the Commission.

The laboratory staff, comprised of approximately 500 people,[10] is especially competent and experienced in the development and application of the technology of graphite moderated reactors, development and evaluation of new fuel element concepts, and the development and application of solvent extraction processes for radiochemical refining, in addition to its biology skills.

Until recent years, the efforts of the Laboratory were placed principally on supporting the plutonium production program. Within the last 3 years, an increasing amount of nuclear technology and civilian reactor research and development work has been assigned to the Hanford Laboratory, notably the plutonium recycle test reactor, to demonstrate the feasibility of utilizing plutonium as a power reactor fuel.

The Hanford Laboratory is especially well equipped with facilities and technical manpower for the support of major reactor development objectives. At present, the Laboratory is heavily engaged in the convertible production reactor project and the plutonium recycle program. It is also performing graphite research work for Oak Ridge in support of the gas-cooled reactor project.

Hanford Laboratory, Richland, Wash.: 10-year trend—Costs, staff, and facilities

[Dollar amounts are in millions]

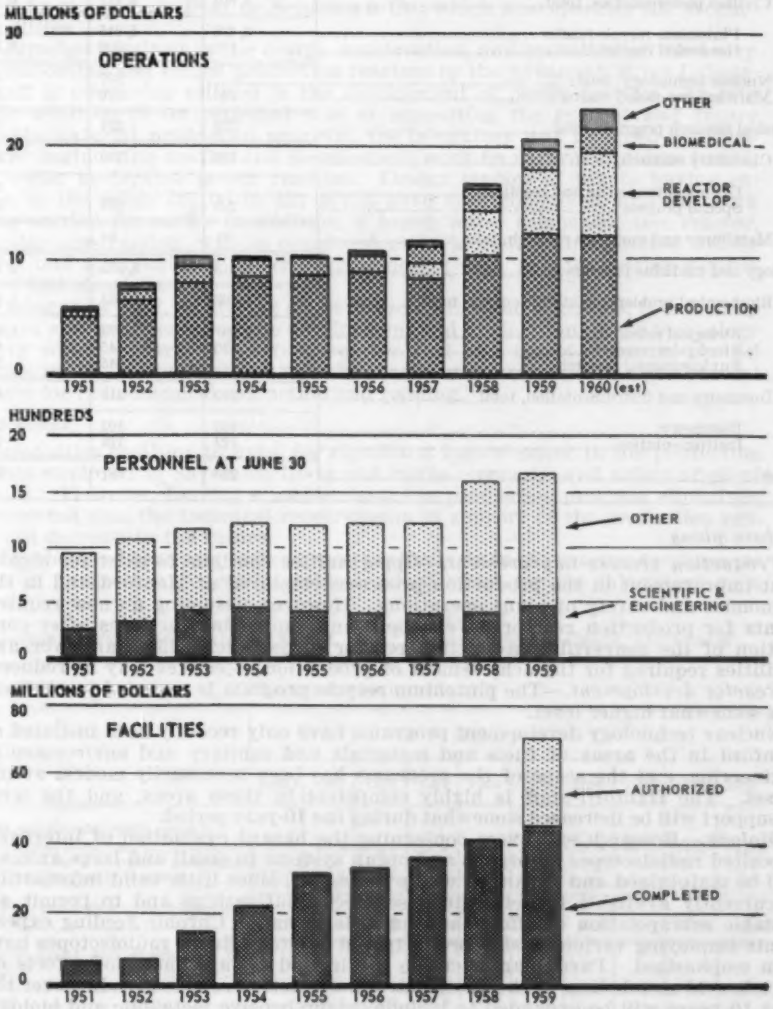
	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	$12.4	$12.6	$10.4	$8.3	$9.0	$8.8	$8.7	$8.1	$6.3	$4.9
Reactor development program:										
Civilian power reactors	6.3	5.4	3.6	1.2	------	------	------	------	------	------
Merchant ship	.2	.6	.3	.1	------	------	------	------	------	------
General reactor research and development	.5	.3	------	------	------	------	------	------	------	------
Total reactor development	7.0	6.3	3.9	1.3	------	------	------	------	------	------
Biology and medicine program:										
Biomedical problems in atomic energy operations	1.8	1.7	1.6	1.4	1.2	1.1	[3]	------	------	------
Dosimetry and instrumentation	.4	.3	.3	.3	.2	.2	------	------	------	------
Total biology and medicine	2.2	2.0	1.9	1.7	1.4	1.3	1.3	1.3	1.1	.9
Other	1.5	1.0	.6	.4	.4	.2	.3	.8	.4	------
Total research and development	23.1	21.9	16.8	11.7	10.8	10.3	10.3	10.2	7.8	5.8
Completed plant and equipment at June 30:[4]										
Accelerators	------	.3	.3	.3	.3	.3	------	------	------	------
Reactors	------	.1	.1	------	------	------	------	------	------	------
Other	------	45.3	41.5	36.7	33.2	31.4	21.7	15.0	6.5	6.0
Total	------	45.7	41.9	37.0	33.5	31.7	21.7	15.0	6.5	6.0
Personnel at June 30:										
Scientific and engineering	------	470	415	405	410	420	460	430	335	260
Other	------	1,205	1,185	820	815	780	765	745	740	690
Total employees	------	1,675	1,600	1,225	1,225	1,200	1,225	1,175	1,075	950

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available in this and prior years.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $24.5 million.

[10] In addition there are about 80 people, such as those in the analytical laboratories, whose efforts are distributed over many programs and who are not included in the count of employees of Hanford Laboratory as described here.

HANFORD LABORATORY

RESEARCH AND DEVELOPMENT



Hanford Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$16,808	$21,890	$23,096
Production process development, total	10,391	12,606	12,400
Reactor development program, total	3,945	6,294	6,975
Civilian power reactors, total	3,601	5,417	6,350
Plutonium recycle reactor	3,470	5,215	5,000
Gas cooled reactor	131	202	1,350
Nuclear technology, total		307	450
Maritime gas cooled reactor	344	570	175
Physical research program, total	279	334	574
Chemistry research, total	228	270	504
Chemical properties and reactions			100
Special projects	228	270	404
Metallurgy and materials research, total	51	64	70
Biology and medicine program	1,913	1,975	2,198
Biochemical problems in atomic energy, total	1,603	1,664	1,857
Biological research	1,067	974	1,086
Biophysics research	536	445	476
Environmental research		245	295
Dosimetry and instrumentation, total	310	311	341
Dosimetry	188	192	209
Instrumentation	122	119	132
Other	280	681	949

Future plans

Production process improvement.—Opportunities continue to exist for significant improvement in the production processes employed at Hanford and in the economics and safety of plant operations. However, assuming no new requirements for production reactor development and supporting facilities after completion of the convertible production reactor project, scientific manpower and facilities required for the achievement of production objectives may be reduced.

Reactor development.—The plutonium recycle program is expected to continue at a somewhat higher level.

Nuclear technology development programs have only recently been initiated at Hanford in the areas of fuels and materials and sanitary and environmental engineering, and the scope of the programs has been necessarily modest at the outset. The Hanford staff is highly competent in these areas, and the level of support will be increased somewhat during the 10-year period.

Biology.—Research endeavors concerning the hazard evaluation of internally deposited radioisotopes on organs and organ systems in small and large animals will be maintained and expanded where necessary, since little valid information is currently available to delineate dose-effect relationships and to permit acceptable extrapolation of effects and hazards to man. Chronic feeding experiments employing various fission products and reactor effluent radioisotopes have been emphasized. Particular attention is directed toward radiation effects on nucleic acid metabolism of the gastrointestinal tract. Projected studies over the next 10 years will be expanded to include comprehensive metabolic and biologic response studies concerning plutonium 239, strontium 90, calcium 45, radium 226, zinc 65, phosphorous 32, and ruthenium 106.

Development of the use of miniature swine as an experimental animal will be emphasized. Studies concerning removal of internally deposited isotopes such as plutonium will be expanded. The addition of studies on the factors affecting the permeability and absorptive properties of cells toward radionuclides is urgently needed.

In total, the level of effort in the biology program is expected to be increased modestly over the decade.

Savannah River Laboratory

The first reactor at the Savannah River plant began operation 6 years ago. Process development work at the site, however, had begun 2 years earlier and, from the beginning, the results of that work made possible economies in design and operation of the production facilities. The last of the production reactors went critical in early 1955 and, until that time, research and development activities were directed almost exclusively toward the primary production mission of the plant. For that purpose, laboratory, semiworks and support facilities valued at $45 million have been provided at the plant site. The laboratory is operated by the E. I. du Pont de Nemours & Co., which also operates the production facilities.

The experience gained in the design, construction, and operation of the heavy water moderated and cooled production reactors by the Savannah River Laboratory staff is now being utilized in the development of power reactors. In late 1956, in addition to its principal role of supporting the current and future fissionable material production program, the laboratory was assigned responsibility for engineering studies and development work on natural uranium fueled, heavy water moderated power reactors. Design studies of plants having capacities in the range of 100 to 425 MWE have been completed, and the work is being carried forward. In addition, a heavy water component test reactor, now under construction, will be completed early in 1961. This reactor will be a useful tool for obtaining power reactor design data and for testing various types of fuel elements.

The laboratory staff, employing about 300 scientists and engineers, is especially competent and experienced in the development and application of the technology of heavy water moderated reactors, reactor fuel and target elements, control instrumentation, mechanical and chemical engineering equipment, and chemical processes for radiochemical extraction and refining.

Future plans

Opportunities continue to exist for significant improvement in the production processes employed at Savannah River and in the economics and safety of plant operation. However, barring a major change in production program objectives, it is expected that the technical requirements in support of the production program will decrease in the future.

It is anticipated that new assignments, particularly in the reactor development field, will result in a generally stable level of effort for the laboratory as a whole.

Savannah River Laboratory, Aiken, S.C.: 10-year trend—Costs, staff, and facilities

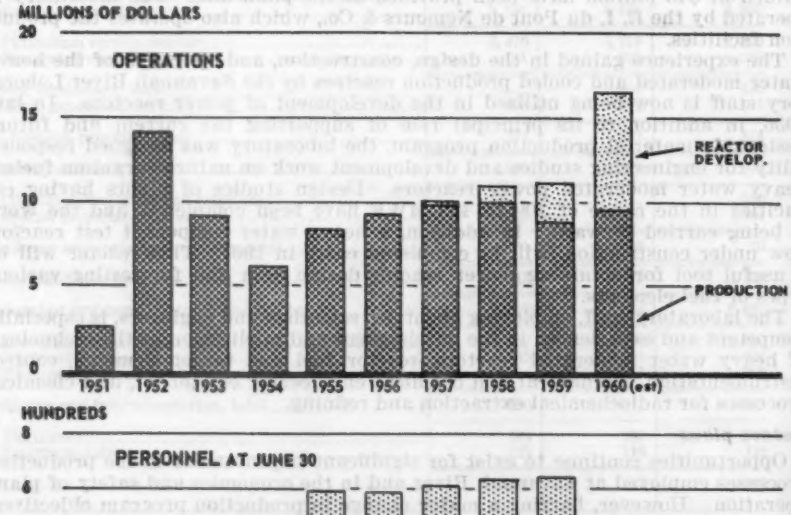
[Dollar amounts are in millions]

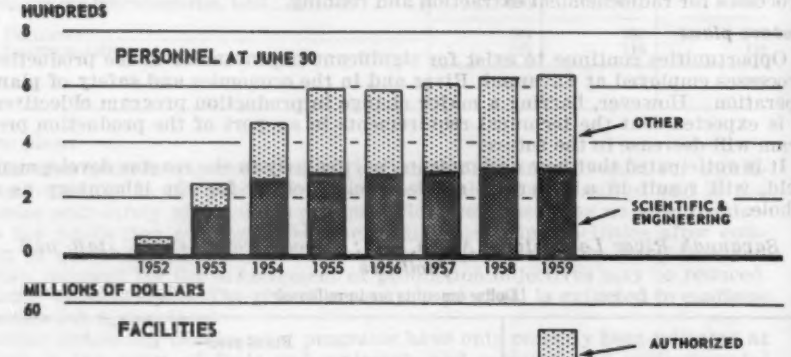
	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Production program	$8.9	$8.8	$10.1	$10.0	$9.4	$8.5	$6.5	$9.5	$14.2	$2.5
Reactor development program:										
Civilian power reactors	7.0	2.6	1.1	.3	------	------	------	------	------	------
Total, research and development costs	15.9	11.4	11.2	10.3	9.4	8.5	6.5	9.5	14.2	2.5
Completed plant and equipment at June 30:[4]										
Reactors	------	16.2	16.1	16.1	16.1	8.6	------	------	------	------
Other	------	28.4	25.2	24.8	21.3	------	------	------	------	------
Total	------	44.6	41.3	40.9	37.4	8.6	------	------	------	------
Personnel at June 30:										
Scientific and engineering	------	300	300	296	291	292	265	162	31	(3)
Other	------	335	330	315	299	299	204	89	23	------
Total employees	------	635	630	611	590	591	469	251	54	------

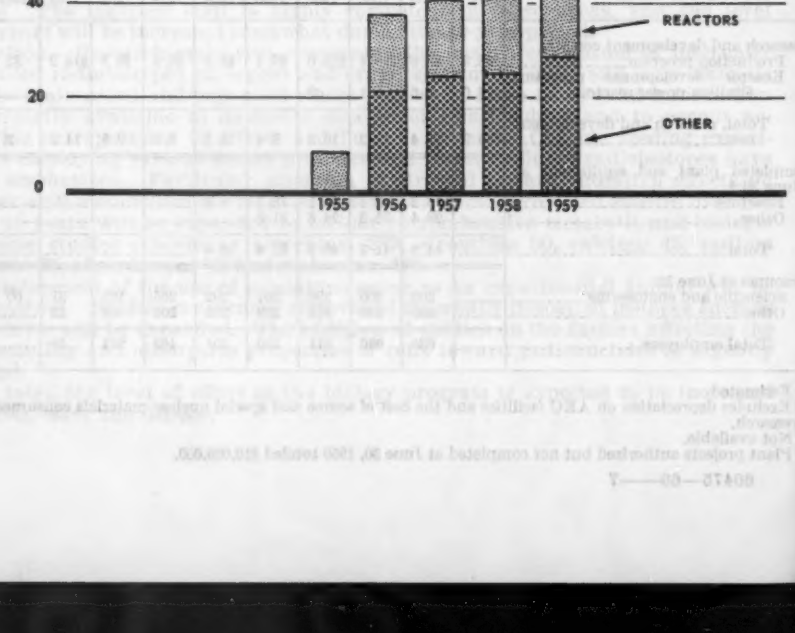
[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Not available.
[4] Plant projects authorized but not completed at June 30, 1959 totaled $10,000,000.

SAVANNAH RIVER LABORATORY

RESEARCH AND DEVELOPMENT







Savannah River Laboratory: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$11,149	$11,356	$15,940
Production process development, total	10,023	8,741	8,940
Reactor development, heavy water reactor, total	1,126	2,615	7,000
Research and development	1,126	2,615	6,640
Fuel fabrication			300
Operations			60

SECTION 8. UNIVERSITY LABORATORIES

Only those Commission-supported activities that are carried on in facilities meeting the criteria of Commission laboratories stated in the introduction are included in this section. In addition to these activities, each of the universities at which these laboratories are situated carries on contract research for the Commission in its own facilities, using varying types and amounts of Government-owned equipment.

Argonne Cancer Research Hospital

The Argonne Cancer Research Hospital began its clinical and laboratory experimental program in the spring of 1953. Its purpose and program are directed toward the exploitation of high-energy radiation sources for the treatment of malignancies; utilization of radioisotopes in the diagnosis and therapy of disease states; and basic research in oncology and hematology; as well as toward the elucidation of certain biologic effects of ionizing radiations.

The physical facilities comprise 56 patient beds available for clinical research, radiochemical laboratories, animal quarters, and 3 sources of high-energy radiations. These latter are a 50-million-electron-volt linear electron accelerator, a 2-million-electron-volt Van de Graaff accelerator, and a 2,200-curie cobalt 60 unit designed for rotational therapy. The radiation sources are available for biological experimentation as well as the therapy of tumors in the human being.

The program of the Argonne Cancer Research Hospital is correlated in general with the broad program of the University of Chicago's Division of Biological Sciences and the university clinics of which it is a part. In addition, close liaison is maintained with the scientific program of Argonne National Laboratory, as, for example, in joint studies of radium dial painters to determine the effects of the body burden of radium they carry.

Future plans

With the recently completed 50-million-electron-volt linear accelerator now in operation and being used in the treatment of patients, this cancer research facility is now considered to have reached a stable operational level. The main mission of the hospital will continue to be that of conducting extensive studies on hospitalized patients using radioisotopes therapeutically, diagnostically, and as tracers in metabolic experiments.

Argonne Cancer Research Hospital, Chicago, Ill.: 9-year trend—Costs, staff, and facilities

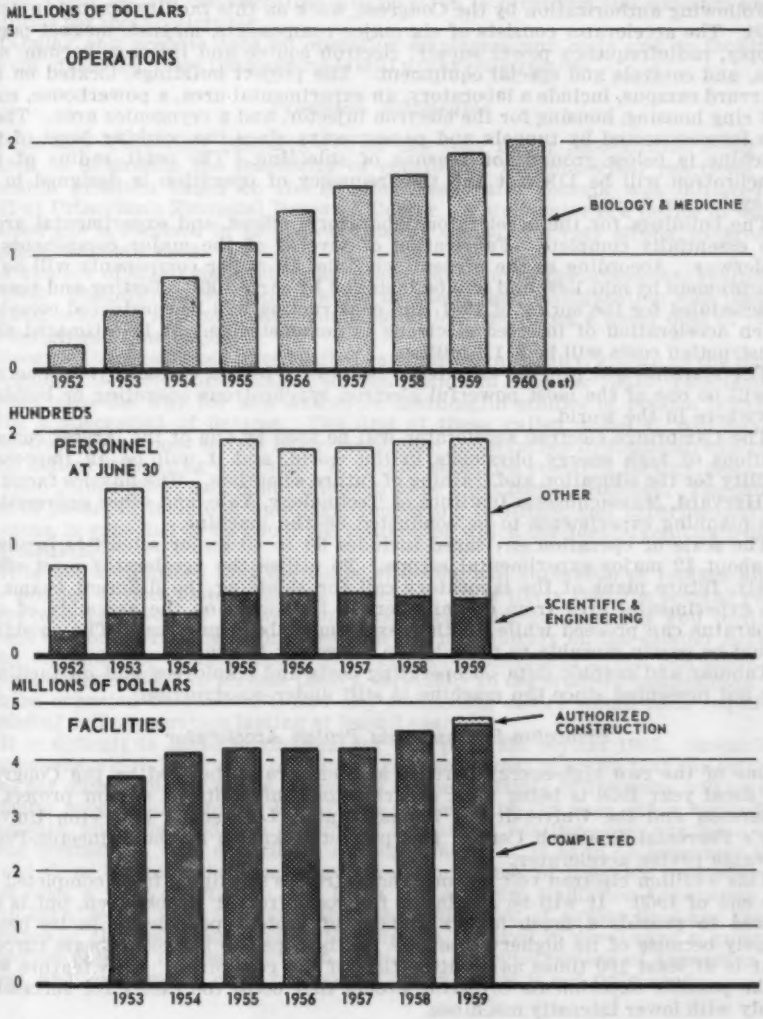
[Dollar amounts are in millions]

	Fiscal year—								
	1960 [1]	1959	1958	1957	1956	1955	1954	1953	1952
Research and development costs: [2]									
Biology and medicine program: Beneficial applications of atomic energy	$2.0	$1.9	$1.7	$1.6	$1.4	$1.1	$0.8	$0.5	$0.1
Total research and development costs	2.0	1.9	1.7	1.6	1.4	1.1	.8	.5	.1
Completed plant and equipment at June 30 [3]	------	4.6	4.5	4.2	4.2	4.2	4.1	3.7	------
Personnel at June 30:									
Scientific and engineering	------	50	51	53	52	52	[1] 37	[1] 37	[1] 2
Other	------	142	140	132	131	140	[1] 117	[1] 112	[1] 6
Total employees	------	192	191	185	183	192	154	149	8

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Plant projects authorized but not completed at June 30, 1959, totaled $0.1 million.

ARGONNE CANCER RESEARCH HOSPITAL

RESEARCH AND DEVELOPMENT



Cambridge electron accelerator

New discoveries in high energy physics and extremely heavy operating schedules demanded of the Cosmotron at Brookhaven and the Bevatron at Berkeley clearly demonstrated the need for additional high energy accelerators. Consequently, in 1955, the Commission approved a program to construct and operate two additional multibillion electron volt accelerators at university sites. In March 1956 the Commission selected the joint proposal of Harvard University and the Massachusetts Institute of Technology to construct and operate one of the two machines.

Following authorization by the Congress, work on this facility started in April 1956. The accelerator consists of six major components, magnet, magnet power supply, radiofrequency power supply, electron source and injector, vacuum system, and controls and special equipment. The project buildings, located on the Harvard campus, include a laboratory, an experimental area, a powerhouse, magnet ring housing, housing for the electron injector, and a cryogenics area. These are interconnected by tunnels and passageways since the working level of the machine is below ground for reasons of shielding. The orbit radius of the synchrotron will be 118 feet and the frequency of operation is designed to be 60 cycles per second.

The buildings for the accelerator, laboratory, offices, and experimental areas are essentially complete. Fabrication of several of the major components is underway. According to the present schedule, all major components will be in procurement by mid-1960 and will be installed by early 1961. Testing and tuneup is scheduled for the spring of 1961, and construction will be considered complete when acceleration of injected electrons is demonstrable. It is estimated that construction costs will be $11.6 million.

The machine will provide an intense beam of 6 billion electron volts energy; it will be one of the most powerful electron synchrotrons operating or building anywhere in the world.

The Cambridge electron accelerator will be used by one of the largest concentrations of high energy physicists in the world, and it will be an important facility for the education and training of future scientists. The physics faculties at Harvard, Massachusetts Institute of Technology, Yale, and other universities are planning experiments to be conducted on the machine.

The scale of operation envisaged includes 30 to 40 senior scientists involved in about 12 major experimental setups. To utilize the accelerator most effectively, future plans of the laboratory call for shielding the different beams in the experimental area from one another, so that work on the assembly of one apparatus can proceed while another experiment is in progress. The shielding would be partly movable to provide the necessary flexibility.

Tabular and graphic data on operating costs and employees and on facilities are not presented since the machine is still under construction.

Princeton-Pennsylvania Proton Accelerator

One of the two high-energy particle accelerators authorized by the Congress for fiscal year 1956 is being built at Princeton University as a joint project of Princeton and the University of Pennsylvania. Located at Princeton University's Forrestal Research Center, this project is known as the Princeton-Pennsylvania proton accelerator.

This 3-billion electron volt proton synchrotron is scheduled to be completed by the end of 1960. It will be similar to the cosmotron at Brookhaven, but is designed to provide a much higher number of protons per second in its beam, largely because of its higher pulse rate. It is hoped to achieve a beam current that is at least 100 times as great as that of the cosmotron. This feature will make possible experiments involving events that occur too rarely for successful study with lower intensity machines.

Being located on a university campus, the accelerator will draw most of its scientists from the ranks of faculty and graduate students of the two universities participating in the project and from neighboring institutions. The whole orientation of the project is toward basic research in nuclear matters and the training of scientists in this field.

This project is expected to cost nearly $12 million. Work was undertaken in April 1956. Princeton and Pennsylvania are contributing some $500,000 toward its cost. Component parts of the accelerator will be magnet, magnet power sup-

ply, injection system, radiofrequency power system, vacuum system and controls, and necessary buildings, laboratories, and other supporting facilities. Certain classes of experiments cannot be performed with the presently planned internal proton beam; full extraction of external proton beams will be nevessary if the full research and utility potential of high-energy machines are to be realized. Experiments such as proton scattering, study of direct proton interactions using bubble chambers, and detection of very short lived particles would be practicable only with a well-shielded external beam. Therefore, during the period under review, consideration will be given to providing full external beam facilities for this accelerator.

Tabular and graphic data on operating employees and costs and on facilities are not presented, since the machine is still under construction.

Princeton Stellarator

Princeton University operates one of the four major laboratories doing research to determine the feasibility of controlling thermonuclear reactions. A research program based on the so-called stellarator concept was initiated in 1951 at Princeton's Forrestal Research Center. A stellarator is a device in which ionized gas is confined in an endless tube by means of a very strong, externally applied, magnetic field.

A number of small stellarators have been constructed in successsion, beginning in 1952. Stellarators, with their novel magnetic field configuration and plasma heating schemes, are inherently complex devices requiring a great deal of careful design and fabrication.

Because the small ones have limited capabilities, a facility, known as the model C complex, is under construction, for completion in calendar 1961. This facility should open the way for new and more meaningful studies of plasma behavior using a succession of devices. The first of these, called model C, will have a "racetrack tube about 40 feet in circumference and 8 inches in diameter, equipped with helical stabilizing windings. It will be strictly a research facility, designed to yield information, and is not intended to be a net power producer. The initial cost of model C, including buildings, supporting facilities, and experimental apparatus, is expected to be about $35 million, of which the plant facilities will be $9.9 million.

It is not anticipated that the model C device will supersede or replace all of the smaller devices under study at Princeton. It is likely that for several years there will be areas of research on plasma confinement, stability and heating, which can be carried out more economically and quickly on the smaller devices than on model C. Furthermore, the Princeton theoretical group has made excellent contributions to plasma theory, especially to the study of instabilities. It can be expected that model C and any succeeding device would each require a period of active operation lasting at least 2 years.

It is difficult to make predictions for this program beyond 1965. Instability phenomena which have come to light make it somewhat doubtful that the original plan for ohmic heating of the plasma up to energy levels of 100 volts will be sufficiently successful in model C. If this proves to be the case, other methods—magnetic pumping and ion cyclotron resonance heating—are available. If these methods in turn experience serious difficulties, it is to be presumed that model C, or its immediate successor, would make use of injection methods. In that case, a joint effort with Oak Ridge or Lawrence Radiation Laboratory, or with both, would seem desirable from the standpoint of saving time and funds, because of the costs that would otherwise be involved in developing a group of injection experts independently at Princeton, the construction of apparatus for them, and the standby costs for model C whenever it is not fully used.

Princeton Stellarator, Princeton, N.J.: 9-year trend—Costs, staff, and facilities

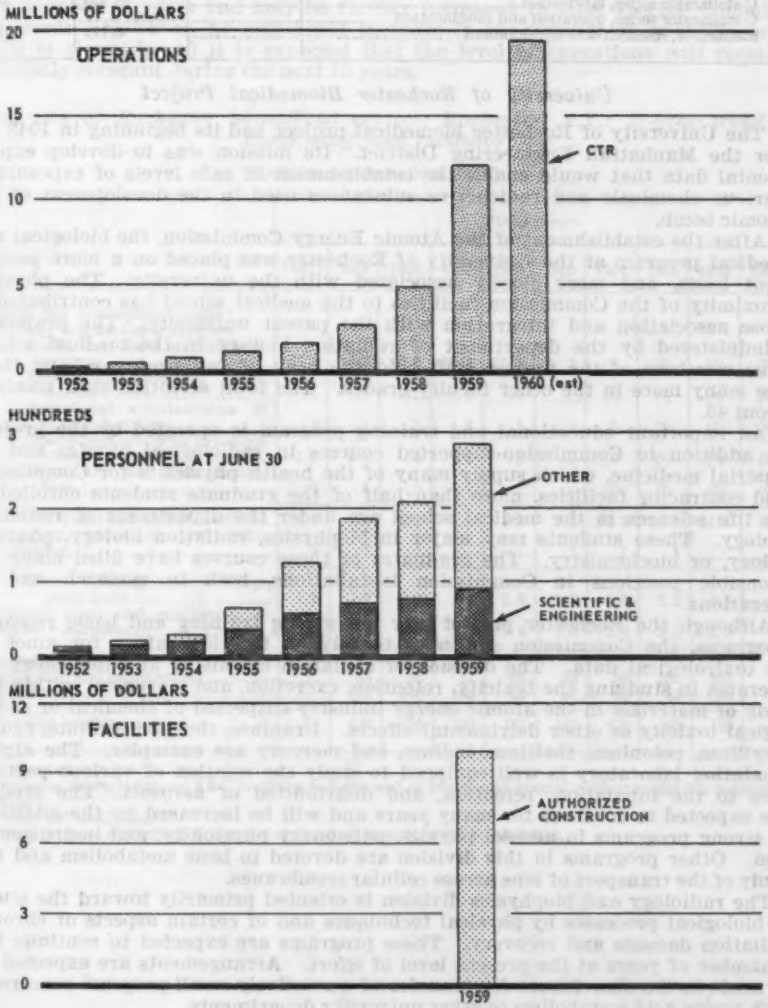
[Dollar amounts are in millions]

	Fiscal year—								
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952
Research and development costs:[2]									
Physical research program: Controlled thermonuclear research	$19.4	$12.0	$4.9	$2.6	$1.5	$1.0	$0.6	$0.4	$0.1
Total research and development costs	19.4	12.0	4.9	2.6	1.5	1.0	.6	.4	.1
Plant projects authorized but not completed at June 30, 1959	------	9.9	------	------	------	------	------	------	------
Personnel at June 30:									
Scientific and engineering	------	89	77	70	54	34	18	13	7
Other	------	194	130	114	70	28	9	3	1
Total	------	283	207	184	124	62	27	16	8

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and nuclear materials consumed in research.

PRINCETON STELLARATOR

RESEARCH AND DEVELOPMENT



Princeton Stellarator: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Physical research program: Controlled thermonuclear research, total	$4,897	$11,975	$19,364
General research and development		330	629
C stellarator series, fabrication		8,470	14,697
C stellarator series, operation and modification			460
Stellarator, research and development		3,175	3,578

University of Rochester Biomedical Project

The University of Rochester biomedical project had its beginning in 1943 under the Manhattan Engineering District. Its mission was to develop experimental data that would enable the establishment of safe levels of exposure to various chemicals and radioactive substances used in the development of the atomic bomb.

After the establishment of the Atomic Energy Commission, the biological and medical program at the University of Rochester was placed on a more permanent basis, and more closely associated with the university. The physical proximity of the Commission facilities to the medical school has contributed to close association and integration with the parent university. The project is administered by the department of radiation biology in the medical school. Nine members of the project staff hold the rank of full professor, and there are many more in the other faculty grades. The total scientific staff numbers about 45.

An important educational and training program is operated by the project. In addition to Commission-supported courses in radiological physics and industrial medicine, which supply many of the health physicists for Commission and contractor facilities, more than half of the graduate students enrolled in the life sciences in the medical school are under the department of radiation biology. These students may major in biophysics, radiation biology, pharmacology, or biochemistry. The graduates of these courses have filled many responsible positions in Commission installations, both in research and in operations.

Although the Rochester project now has strong training and basic research programs, the Commission continues to rely on this laboratory for much of its toxicological data. The division of radiation chemistry and toxicology cooperates in studying the toxicity, retention, excretion, and movement within the body of materials in the atomic energy industry suspected of chemical or radiological toxicity or other detrimental effects. Uranium, thorium, radium, radon, beryllium, polonium, thallium, indium, and mercury are examples. The alpha-inhalation laboratory is well equipped to study the relation of various particle sizes to the inhalation, retention, and distribution of aerosols. The studies are expected to continue for many years and will be increased by the addition of strong programs in aerosol physics, pulmonary physiology, and instrumentation. Other programs in this division are devoted to bone metabolism and the study of the transport of ions across cellular membranes.

The radiology and biophysics division is oriented primarily toward the study of biological processes by physical techniques and of certain aspects of chronic radiation damage and recovery. These programs are expected to continue for a number of years at the present level of effort. Arrangements are expected to be made in the near future for transfer of a relatively small program concerned with amino acid metabolism to other university departments.

The medical division carries out metabolic studies in irradiated animals, and devises and tests various clinical procedures for promoting recovery from acute radiation damage. This program is expected to decrease in activity unless radically new antiradiation drugs are developed. It is anticipated that the medical division will decrease the level of its experimental program on acute effects of radiation in animals and pay increased attention to long-term effects of the type likely to occur in human populations occupationally exposed to radiation and radioactive materials.

A small but significant program, both basic and applied, on the production of burns by short, intense flashes of thermal radiation has supplied the AEC with most of its knowledge of the processes involved and possible methods for protection from burns caused by nuclear weapons. This work is essentially complete and will be phased out during the next 2 years. The basic program in physical measurements will probably be transferred to the Institute of Optics.

During the past few years the staff of the project has paid increasing attention to the programs dealing with long-term, low-level effects of radiation in several species of laboratory animals. These studies are expected to continue for a number of years and may be further increased to meet specific Commission needs. However, no significant increase in the number of scientific personnel is planned, and it is expected that the level of operations will remain essentially constant during the next 10 years.

University of Rochester biomedical project, Rochester, N.Y.: 10-year trend—Costs, staff, and facilities

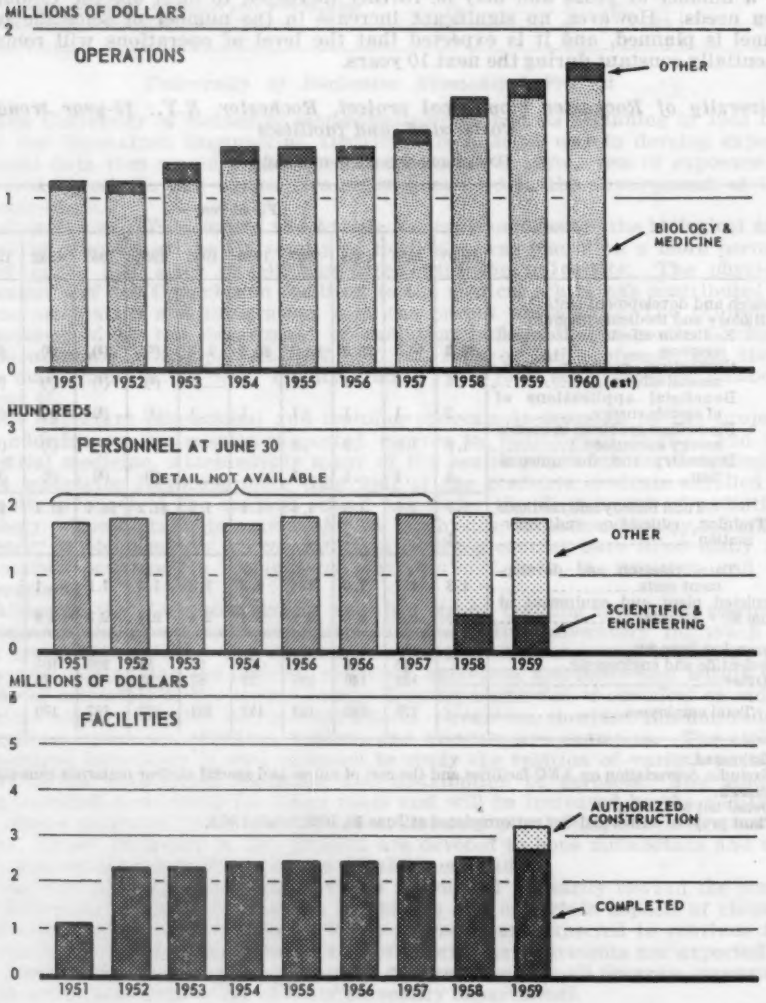
[Dollar amounts are in millions]

	Fiscal year—									
	1960[1]	1959	1958	1957	1956	1955	1954	1953	1952	1951
Research and development costs:[2]										
Biology and medicine program:										
Radiation effects on biological systems	$0.3	$0.3	$0.3	$0.3	$0.3	0.3	(3)	(3)	(3)	(3)
Combating radiation detrimental effects	.1	.1	.1	.1	.1	------	(3)	(3)	(3)	(3)
Beneficial applications of of atomic energy	.2	.1	.1	.1	.1	.1	(3)	(3)	(3)	(3)
Biomedical problems in atomic energy operations	1.0	1.0	.9	.8	.8	.8	(3)	(3)	(3)	(3)
Dosimetry and instrumentation	.1	.1	.1	.1	------	------	(3)	(3)	(3)	(3)
Total biology and medicine	1.7	1.6	1.5	1.4	1.3	1.2	$1.2	$1.1	$1.1	$1.1
Training, education, and information	.1	.1	.1	------	------	.1	.1	.1	------	------
Total research and development costs	1.8	1.7	1.6	1.4	1.3	1.3	1.3	1.2	1.1	1.1
Completed plant and equipment at June 30:[4] All other	------	2.7	2.5	2.4	2.4	2.4	2.4	2.3	2.3	1.1
Personnel at June 30:										
Scientific and engineering	------	45	46	77	95	94	88	105	101	69
Other	------	133	140	106	92	87	82	82	78	103
Total employees	------	178	186	183	187	181	170	187	179	172

[1] Estimated.
[2] Excludes depreciation on AEC facilities and the cost of source and special nuclear materials consumed in research.
[3] Detail not available.
[4] Plant projects authorized but not completed at June 30, 1959, totaled $0.5.

UNIVERSITY OF ROCHESTER BIOMEDICAL PROJECT

RESEARCH AND DEVELOPMENT



University of Rochester biomedical project: Current budget and recent costs by categories of work

[In thousands]

	Fiscal year 1958 costs	Fiscal year 1959 costs	Fiscal year 1960 budget
Total	$1,618	$1,708	$1,812
Biology and medicine program, total	1,510	1,576	1,672
Radiation effects on biological system, total	291	314	321
Medical research	89	111	113
Biological research	202	203	208
Combating radiation detrimental effects, total	84	114	90
Medical research	84		
Biological research		114	90
Beneficial applications of atomic energy, total	103	137	150
Cancer research	60	96	104
Medical research	43	41	46
Biomedical problems in atomic energy operations, total	960	954	1,050
Medical research	387	954	1,050
Biophysics research	573		
Dosimetry and instrumentation: Instrumentation	56	57	61
Civil effects program, total	16		
Training, education, and information program, total	108	132	140
Fellowships	86	99	100
Other training, education, and information activities	22	33	40

VOLUME II. SUPPLEMENTARY MATERIALS

Note Concerning Release

This report has been prepared in response to a request from the Joint Committee on Atomic Energy of the Congress. It is to be treated as official use only until released by the Joint Committee.

CONTENTS

Explanatory note.
Long-range programs submitted by the laboratories:
Argonne National Laboratory.
Brookhaven National Laboratory.
Oakridge National Laboratory.
Ames Laboratory.
Lawrence Radiation Laboratory:
Berkeley.
Livermore.
Los Alamos Scientific Laboratory.
Sandia Laboratory.
Hanford Laboratory.
Savannah River Laboratory.
Research and development plant authorized but not completed: June 30, 1959.

Explanatory Note

Beginning in the latter half of 1958, the Commission has asked a number of the laboratories, including all of the multiprogram institutions, to prepare long range programs for consideration. It was anticipated that such programs would be helpful in planning the work not only of the individual institutions, but of the agency as a whole.

This supplementary volume is made up mainly of these long range program statements as prepared by the laboratories, or of condensations of such statements. The Commission's present thinking as to the laboratory programs for the next 10 years is summarized for each laboratory in volume I, part II, of this report. There are, of course, a number of differences between the program projections presented by laboratories in these supplements and the Commission's plans set forth in the preceding volume. The differences for the most part arise

from the fact that the Commission's plans contemplate more stable size or more limited growth than do the forecasts of some of the laboratories; in some cases the Commission's plans do not concur in the entry of a laboratory into a new field.

The final section contains a listing of Commission research and development facilities authorized but not completed at June 30, 1959.

Long Range Programs Submitted by the Laboratories

Summary of Long Range Program Submitted by Argonne National Laboratory[1]

(Sec. I of this summary sets forth highlights of the program as projected by the Laboratory, including tabular summaries of facility and personnel requirements. Sec. II presents a more comprehensive summary of the program in outline form.)

Section I. Highlights

1. Physical science research is now principally in low energy physics; work also is carried on in general chemistry with particular emphasis on the heavy elements, high-temperature research, solid-state science, and physical metallurgy. Significant expansions are proposed in high-energy nuclear physics, solid-state science, high-temperature research, the physical metallurgy of plutonium, electronic instrumentation in general, and computing devices in particular.

2. Life science emphasis currently is on effects of radiation on living systems, including studies of the effects of both internal and external radiation on animals and epidemiological studies of exposed human beings. An immediate practical aspect is the evaluation of hazards and the setting of permissible dose rates. Tracer techniques are used in studies in plant science, and labeled organic compounds are produced by growing plants in special growth chambers.

Major expansions are contemplated in the study of the chronic effects of continued irradiation of animals at low levels of intensity, and in plant science.

3. Reactor development and engineering work at the Laboratory is now directed principally toward the development of reactors for civilian uses with emphasis on the breeding principle. Future emphasis is proposed to focus on general engineering research fields rather than on specific reactor problems.

(*a*) General engineering research includes reactor physics, heat engineering, reactor control, metallurgy related to reactors, chemical engineering involved in the processing of fuels, remote control and meteorology (as it bears on reactor safety); a general expansion is proposed for work in this area with the most striking increase in micrometeorology.

(*b*) Specific reactor problems fall into the general categories of boiling-water reactors, fast reactors, and special-purpose reactors (such as high-flux research reactors). Tapering off of laboratory work on boiling-water reactors is foreseen. Future emphasis appears aimed at fast reactors with their associated problems in metallurgy, chemical engineering, and remote control; there is no end to the list of possible special-purpose reactors.

4. Educational responsibilities are more capable of being met under the increasing relaxation of security restrictions. Laboratory activities in this field, frequently in cooperation with midwestern colleges and universities, include appointments for senior faculty members on sabbatical (or other) leave; 2-year post-doctoral research appointments; appointments for graduate students to carry out research for their master's and doctor's theses; summer appointments for faculty members and graduate students; appointments for undergraduates, including cooperative students; and, finally, summer institutes for faculty members of engineering colleges and technical institutes. An increase from the present approximately 10 percent of staff effort at the Laboratory to at least 20 percent is proposed over the next few years.

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[1] Dated March 1959.

5. *Facilities and personnel.*—

(*a*) Facilities expansions, totaling $167 million, can be grouped in three categories as follows:

(1) Specialized research and development facilities, including such items as new reactors, additions to presently existing or authorized facilities, such as the ZGS, and maintenance and improvements to these facilities.

(2) Laboratory and office space.

(3) General service facilities.

(*b*) Personnel strength is proposed to be expanded from the current 3,450 to 5,850 by 1964 and 6,700 by 1969.

TABLE I.[1]—*Estimate of staff requirements, scientific and technical divisions*

	1959 [2]	1964	1969
Analytical services	(17)	30	35
Applied mathematics	27	65	75
Biology and medical	79	104	120
Chemistry	139	180	185
Chemical engineering	91	160	168
Computer research and development	(4)	15	30
Electronics	30	75	100
High-energy physics	(5)	100	150
Idaho	26	65	65
International School	18	25	25
Metallurgy	80	143	160
Meteorology	(4)	15	20
Particle accelerator operation and development	41	75	100
Physics	76	95	100
Plant sciences	(5)	60	80
Radiological physics	22	26	27
Reactor engineering	202	250	260
Reactor operations	6	30	35
Remote control	25	59	65
Solid-state sciences	(15)	50	80
Technical information	23	28	45
Total staff	885	1,650	1,925

[1] In tables I and II the term "staff" refers only to academically qualified scientists and engineers engaged in their professional capacities directly on the research and development program of the Laboratory. The term "direct support" refers to technicians, secretarial assistance, and certain administrative assistance assigned directly to the divisions responsible for the research and development program. The term "supporting technical services" includes primarily the machine shop, the industrial hygiene and safety and the medical personnel regardless of any professional classification.

The staff requirements for the scientific and technical divisions are presented in table I essentially along divisional organization lines. However, in those cases where the long-range program of the Laboratory indicates significant expansion which might not fit into the present divisional pattern or which might affect programs in more than one division, the pertinent staff figures are itemized separately. The staff numbers in table I include temporary personnel which, at present, account for about 10 percent of the total staff. It is expected that this will increase to about 20 percent in the next few years. The temporary personnel would consist primarily of individuals with temporary postdoctoral appointments and faculty members from universities on temporary leaves or sabbaticals. The percentage of temporary appointments will undoubtedly vary widely, ranging from only a few percent in the case of divisions with large programmatic responsibilities to perhaps 50 percent or greater in the case of high-energy physics research.

[2] Numbers in parentheses under 1959 represent staff members currently carried under other divisional totals.

TABLE II.[1]—*Summary of estimated personnel requirements*

	1959	1964	1969
Scientific and technical divisions staff	885	1,650	1,925
Scientific and technical divisions direct support	864	1,550	1,825
Supporting technical services	595	990	1,050
General services and administration	1,060	1,615	1,850
Laboratory Director's office	35	45	50
Total	3,439	5,850	6,700

[1] In tables I and II the term "staff" refers only to academically qualified scientists and engineers engaged in their professional capacities directly on the research and development program of the Laboratory. The term "direct support" refers to technicians, secretarial assistance, and certain administrative assistance assigned directly to the divisions responsible for the research and development program. The term "supporting technical services" includes primarily the machine shop, the industrial hygiene and safety and the medical personnel regardless of any professional classification.

The staff requirements for the scientific and technical divisions are presented in table I essentially along divisional organization lines. However, in those cases where the long-range program of the Laboratory indicates significant expansion which might not fit into the present divisional pattern or which might affect programs in more than one division, the pertinent staff figures are itemized separately. The staff numbers in table I include temporary personnel which, at present, account for about 10 percent of the total staff. It is expected that this will increase to about 20 percent in the next few years. The temporary personnel would consist primarily of individuals with temporary postdoctoral appointments and faculty members from universities on temporary leaves or sabbaticals. The percentage of temporary appointments will undoubtedly vary widely, ranging from only a few percent in the case of divisions with large programmatic responsibilities to perhaps 50 percent or greater in the case of high-energy physics research.

In table II are listed the total personnel requirements of the Laboratory. Given first the number of staff, the requirements for direct support, for the supporting technical services and for general services and administration have been based on the experience of the last several years with suitable allowance being made for the trends indicated in the long-range scientific and technical program. Thus, the increased use of higher levels of radioactivity will mean an increase in ratio of personnel involved in radiation safety activities to the total staff. The rapid expansion of the Idaho reactor program likewise will result in an increased ratio of service personnel to total staff. On the other hand, the decrease in security and classification problems should decrease the ratio of service personnel to staff. From the overall standpoint, the sum of such trends is expected to result in a significant decrease in the ratio of total service personnel to total staff as the size of the staff grows. This is borne out by the trends in recent years.

TABLE III.—*Current status of facilities*

	Estimated	
	Completion	Cost
Facilities currently under construction:		
Zero gradient synchrotron	January 1963	$29, 800, 000
Experimental breeder reactor II (Idaho)	December 1960	29, 100, 000
Fuels technology center	November 1961	17, 000, 000
Fuel fabrication facility	April 1959	4, 000, 000
EBWR improvements (100 MW)	March 1960	1, 600, 000
CP-5 improvements (10 MW)	March 1960	880, 000
Biology building addition—Dog kennels	December 1959	600, 000
Coincidence beta spectroscopy facility (chemical building addition)	September 1959	500, 000
Biology reactor ("Janus")	March 1960	330, 000
Fast source reactor (Idaho)	July 1959	120, 000
Total		83, 930, 000
Facilities authorized by Congress—Construction not started:		
Chemistry hot laboratory	(1)	4, 500, 000
Zero power reactor facilities	December 1960	3, 000, 000
Tandem Van de Graaff (10 Mev)	(1)	2, 500, 000
Borax V	June 1960	2, 000, 000
Total		12, 000, 000
Facilities included in fiscal year 1960 congressional authorization request:		
Utility additions		3, 000, 000
Radioactive waste processing plant		1, 300, 000
EBR-I—Modifications		1, 000, 000
Education and training (east area modifications)		1, 000, 000
Animal quarters addition		500, 000
Total		6, 800, 000
Facilities considered for inclusion in the fiscal year 1961 Argonne budget request:		
Zero gradient synchrotron—Additions		10, 000, 000
High energy physics building		5, 000, 000
High flux research reactor		15, 000, 000
Chemical engineering laboratory addition		2, 000, 000
Applied mathematics (physics building addition)		2, 000, 000
Reactor engineering building		3, 000, 000
Solid state science building		5, 000, 000
Heating plant—Additional boiler		1, 500, 000
Administration building (includes Chicago operations office)		6, 000, 000
Cafeteria		2, 000, 000
High level alpha gamma hot laboratory		6, 700, 000
Total		58, 200, 000

[1] Funds not yet available.

TABLE IV.—*Facilities to be requested in future years*

Special research and development facilities:		
Zero gradient synchrotron additions		
Meteorological modeling		
Mouse experiment		
Low energy particle accelerator(s)		
Solid state "fast flux" reactor		
Chemical engineering hot laboratory addition		
Library facilities		
Total approximate cost		$60,000,000

Scientific space requirements:

	Net square feet	
	Laboratory	*Office*
Biology and medicine	14,100	5,700
Plant sciences	28,300	11,400
Chemistry	20,300	6,900
Chemical engineering	17,700	6,000
Analytical chemistry	6,200	2,100
Computer development	8,400	4,400
Radiological physics	9,300	4,900
Engineering and electronics	39,900	16,400
Total	144,200	57,800

	Net square feet	
Laboratories	144,200	
Offices	57,800	
Shops	37,300	
Storage and stores	60,300	
Scientific services and special	95,000	
Total net space	394,600	
Total approximate cost (921,000 sq. ft. gross at $38 per square foot)		35,000,000

Supporting services:	
Mechanical shops	
Idaho service and administration	
Industrial hygiene and safety	
Fire security and emergency center	
Auditorium	
Special material vaults	
Maintenance shops	
Warehouse	
Total approximate cost	14,000,000

Section II. Program summary

1. *General discussion.*—

a. The primary purposes of ANL are held to be to contribute toward realization of the potential peacetime benefits of atomic energy by (1) conducting a balanced comprehensive program in basic nuclear research, (2) doing applied research and development to hasten widespread practical applications of nuclear science, and (3) disseminating information in the nuclear field.

b. Functions to be performed to fulfill these purposes include:

(1) Providing objective and competent technical advice to the Commission;

(2) Providing the mechanism necessary to establish and execute the research and development programs necessary for the Commission to attain its objectives;

(3) providing the means for mobilizing the research and development potentials of both universities and industry in support of AEC objectives;

(4) Providing a mechanism for the dissemination of information with respect to the objectives and accomplishments of the atomic energy program.

c. Support from the AEC is required if the Laboratory is to accomplish its purpose. Such support must include:

(1) Active aid in establishing and maintaining adequate staff by providing "good working conditions"—both intellectual and material—and equipment and facilities (20 to 40 percent of annual operating budget to go for equipment and facilities);

(2) Active support of cooperative programs with the universities, industry, other Government agencies and those related to international programs.

d. Limitations on the Laboratory scientific and technical program include:

(1) Atomic Energy Act of 1954 (ch. 1, secs. 1, 2, 3; ch. 4, secs. 31, 32, and 33).

(2) Limitations imposed by relationships with universities. (Laboratory will not put major research effort into an area which is being investigated in a university unless there is an overriding need to obtain the research data in a much shorter period of time than the university effort would require.)

(3) Limitation imposed by relationships with industry. (Laboratory will not build an instrument or a component when it is possible to purchase a fully satisfactory item on the market; also—ANL has adopted the principle of proposing development projects which require the Laboratory's unique facilities and the diverse understandings and skills of its research and development staff, with development carried only to the point at which industry should be able to take over the responsibility for further development.)

e. General character of the Laboratory's scientific and technical program is determined by the needs of the atomic energy program, in terms of the scientific and professional disciplines which experience has shown are needed for successful accomplishment.

(1) Research: Principal responsibility is to attain as complete an understanding of the nature of the nucleus of the atom and of the forces which hold it together as it is possible to achieve through theoretical and experimental investigation.

(2) Applied development work: Basic principle is the timely selection of projects which can make clear contributions to the national welfare.

(3) Education: The educational activities of the Laboratory form an integral part of its scientific and technical program; other programs effective only to the extent that their need and results are used and understood by both the scientific community and the public.

2. *Scientific and technical long-range program proposals.*—

a. Physical sciences:

(1) Low energy physics: Among the branches of low energy physics that will be pursued actively are the following: nuclear spectroscopy, neutron interactions, fission, charged particle reactions, asymmetry of decay in the neutron, and neutrino cross sections.

(2) High energy physics: Relatively new program at ANL. Primary objective of ANL for next few years will be to build, operate, and use the ZGS for experimental research. Expand present small staff to 100–150.

(3) Chemistry:

(*a*) Major effort will center on chemistry of heavy elements, with emphasis on actinide elements; expanding work on transplutonium elements.

(*b*) Expansion of effort in plutonium field.

(*c*) Research on fluorine will continue in at least two major areas: Radioactive F^{18} and the liquid phase chemistry of the reactive fluorides.

(*d*) Continued investgation of properties of liquid and solid He^3 and solutions of He^3 and He^4.

(*e*) Extensive program to measure heat capacities and magnetic susceptibilities of various neptunium, uranium, and thorium compounds between 1 and 350 degrees Kelvin.

(*f*) Basic studies in radiation chemistry and photochemistry. Build a new high-flux reactor at earliest possible date; also, new chemistry hot laboratory to handle high levels of activity.

(4) High-temperature research: Progress is reactor technology and other fields is limited by paucity of basic data concerning the properties of materials at high temperatures. Work in this field must be expanded as rapidly as possible. Doubling of staff is proposed for the next 4 years and another doubling in the following 5 years; in addition to the usual space problem, a factor limiting the rate of expansion in this area may be the national scarcity of qualified personnel.

(5) Solid state: Research is proposed to be increased rapidly, not only in areas currently engaging laboratory personnel, but also in other fields such as the studies of metals, alloys, semiconductors, ferroelectrics, and other nonmetals, and in solid state research at low temperatures. Expand the current 15-staff members to 50 by 1964 and to 80 by 1969; additional facilities required include those for X-ray diffraction and electron diffraction studies and also for further progress in the study of radiation damage a special reactor—to provide adequately thermostated irradiation facilities with temperatures down to the liquid helium range.

(6) Physical metallurgy: Major objectives include the study of the basic metallurgical physical properties of U, Pu, and Th, and the advancement of understanding of the fundamental principles that govern the structures and properties of all solids that appear to be potentially significant for fuure development of nuclear energy. Effort to be continued on principles of corrosion, theory alloys, effects of radiation on the structures of metals and on metallurgical reaction, and the structure and properties of high-temperature ceramic materials. Expanded effort on plutonium and compounds of uranium, plutonium, and thorium means some reduction in work on uranium.

(7) Computer research: Enormous growth in use of computer services has not been matched by adequate research in new computer techniques.

(8) Potential interest in thermonuclear work.

b. Life sciences: Broadly speaking objectives here are the achievement of an understanding of the action of radiation on living systems, and also, the use of radiation to achieve a better basic understanding of life processes. Both animal and plant systems are studied.

(1) Animal studies:

(*a*) Effects of external radiations:

1. Recent trend toward broadening the studies in an attempt to determine the chronic effects produced by continued exposure at or near background levels. Expansion of this effort is proposed; special reactor for this purpose is under design and should be in operation in early 1960.

2. Studies of species and genetic variations, and of the influence of age, sex, and previous history on ray toxicity will be continued and extended to cover fission neutrons.

(*b*) Effects of internal radiations (studies of animals and humans whose body burdens of radium are appreciable):

1. Animals: Expanded effort on the toxicity of fission products and other radioactive materials.

2. Humans: Major goal is establishment of maximum permissible level of radium in man (to be reached within next 5 years). Also, studying relationship between bone sarcoma and radium in drinking water, bone physiology, and seeking discovery of chemical compounds useful in treatment of poisoning by radioelements and metals.

(*c*) Basic studies:

1. Genetic studies: Current work to be continued and expanded.

2. Cancer studies: Direction to be determined by developments in related programs; anticipate increasing attention to predisposing factors in carcino-genesis.

3. Biochemical investigation of problems in general metabolism and the intracellular localization of biochemical events will be continued and broadened to (*a*) provide background information for the interpretation of radiation effects, and (*b*) evaluate physical and biological factors in radiation sensitivity and to develop protective agents.

4. Current studies to determine the effects of radiation and age and growth potential and the regenerative capacity will be expanded to include other parameters.

5. More attention to be given to problems in embryology and to phenomena of cell and tissue differentiation.

6. Studies in theoretical biology will continue at about the present level although more computer time will be used. (Newly initiated work in the study of the fundamental problems in the primary effects of radiation will require the establishment of a group dedicated to this program. The further development of basic and applied radiation dosimetry is imperative.)

(2) Plant sciences: Effort in this area has been small; work must be extended and expanded. (A plant science institute is proposed to carry out a broad program of research in plant science, and to serve as a center for training in the application of specialized tools and techniques to investigations in plant science. This is conceived to be a cooperative laboratory, AMU to play a prominent role, in addition to the U.S. Department of Agriculture, agriculture experiment stations, and others. Total employment, 80 scientific people, 40 regular staff, 40 resident research associates; facilities required include a special biology reactor (Janus) and a biology building addition for dog kennels—construction to begin shortly—plus animal quarters addition (authorized fiscal year 1960); additional animal quarters, office, and laboratory space will be necessary.)

c. Engineering research and development program: This program is comprised of specific reactor programs and general engineering research. (Long-range program contemplates that the staff in general engineering research be doubled (approximately) as soon as possible and specific engineering projects be increased only to the extent necessary to meet current commitments, e.g., EBR II. Work on boiling water to be decreased and emphasis to be directed to fast reactor concepts; associated increased emphasis on plutonium, ceramic fuels, and fuel cycles. Laboratory reemphasizes need for additional reactor engineering building and for the two-wing addition to the chemical engineering building.)

(1) General engineering research:

(*a*) Reactor physics: Gaps in our knowledge exist, forcing empirical or intuitive solutions to vital questions. (It is proposed to emphasize reactor theory, plan for a comprehensive program of physics measurements on water moderated systems, devote added attention to fast reactor physics and critical assemblies, fueled with U^{233} and Pu, explore properties of coupled fast-thermal systems and fast-thorium systems and others, and study applied nuclear physics.)

(*b*) Heat engineering: The heat engineering program at the Laboratory includes studies on the heat transfer properties, etc., of fluids which have application as reactor coolants; main interest at ANL has been in water and sodium with the bulk of effort devoted to water. Work will be continued on water, with an expansion of sodium work anticipated. As efforts to exploit high-temperature reactors increase, additional problems in this area will be encountered.

(*c*) Reactor control engineering: Results of this work are applied directly to existing reactor installations; examples of future work include broadening of program on reactor simulators, improvement of techniques of measurement and analysis, and investigation and development of new control systems.

(*d*) Metallurgy and materials engineering: Aims are to produce fuel elements of simple design, to make high-quality fuel and cladding materials, to design simple, foolproof and automatic manufacturing processes, and to perfect highly refined nondestructive testing techniques for detecting defective materials and components.

(*e*) Chemical engineering:

1. Work directed toward aqueous, volatility, and pyroprocessing of uranium fuels can be finished in some 5 years; future work will be on fuels based on Pu alloys and oxide or ceramic fuels—also fuels of reactors operating on the thorium-uranium breeding cycle.

2. Continue study of promising new separations process in which fluoride volatility processes are carried out in fluidized beds.

3. Continue studying reactor safety problems of a chemical nature.

4. Study problems in reactor chemistry in the proposed slurry reactor programs.

(*f*) Remote control engineering:

1. Direct efforts at problems stemming from greater use of and increasing levels of radioactive materials. (Space is the limiting factor and is needed to house even the present staff adequately.)

2. Work on viewing systems to emphasize shielded windows, optical periscopes, and television.

3. Because of increasing emphasis on plutonium and other highly toxic materials work needed in development of shielded facilities. (One such complete shielded facility vitally needed for the reactor development program of ANL is the proposed alpha-gamma facility to be housed in an addition to building 301.)

(*g*) Meteorology (an area relatively neglected in last 10 years): Seeks to perfect modeling techniques. (Propose to construct a pilot wind tunnel to test various new and untried features and to follow this with a full-scale tunnel,

based on experience with the preliminary device. Costs will run very high but believed warranted.)

(2) Specific reactor programs:

(*a*) Boiling water reactor program (beginning deemphasis of this program): Continuing experimental areas are development of a suitable fuel and fuel cycle, and investigation and evaluation of nuclear superheat for boiling reactors. (A new Borax V is presently under design to permit the evaluation and study of nuclear superheat concepts and to demonstrate nuclear superheating. Another potentially attractive boiling reactor concept is the aqueous homogeneous boiling slurry. This concept appears sufficiently attractive to warrant a Borax I type experiment to establish preliminary feasibility.)

(*b*) Fast reactor program: Late in 1959 a Pu loading will be installed in EBR–I and it is possible that EBR–I will then be used for a ceramic loading. Sometime within the next few years, the fast thermal coupled reactor concept will be investigated in EBR–II. The technology of fast reactors is still in its early stages; a major effort of ANL will be required for perhaps a full 10 years.

(*c*) Research reactor program:

1. Maintain continuing program of theoretical and experimental investigation of various concepts of potential value for research or test reactors.

2. Emphasis exemplified by types currently being worked on—high-flux reactors, relatively low flux special-purpose reactors and pulsed reactors.

3. Design reactor to achieve fluxes above 10^{16}.

4. For those programs which do not need or cannot use high fluxes there is being developed the Juggernaut and the Janus. The TREAT type reactor appears worthy of further study with a view toward other applications.

(*d*) Advanced reactor programs:

1. Gradually shift efforts from boiling water to the study of various advanced reactor concepts. (Relatively simple and inexpensive Borax-type experiments should be carried out whenever possible prior to serious consideration of a prototype.)

2. An extensive development program will be required to extend experience in sodium systems to applicable engineering technology (and other liquid metals).

3. A major Laboratory objective has been the development of very concentrated nuclear power sources; a natural extension is even higher power densities at much higher temperatures. (Process heat, space vehicle propulsion by an ion or plasma jet, or for base power on a satellite or planet, small reactors for remote locations, the direct generation of electricity, and pulsed directly into high pressure waves—shocks.)

4. Investigate two types of reactors which represent advanced development of current laboratory studies, the evolutionary extension of the EBR–II type to higher and higher design temperatures, and the feasibility of the boiling slurry reactor concept (possible boiling of sodium slurry).

5. Possibly develop dry particle fueled reactors (direct fluidized bed concept or the dust fueled approach, alternatively).

d. Education and training: Security and classification climate much improved. Plan to raise the admission requirements for the international school as engineering schools are now offering basic training in nuclear engineering. Continue and increase cooperation with schools and universities.

e. Supporting scientific and technical services: Service functions should be substantially improved and associated research and developmental work should be increased.

(1) Applied mathematics and computers: Lack of space prevents further expansion of computer facilities. Present digital computers are: GEORGE and an IBM–704. (Needs require growth that can be accommodated only by new construction; a third machine, comparable to present ones, will be required. A group should be established for continuing research, and design of computing devices.)

(2) Electronics and instrumentation: Work falls into three principal areas: General electronic instrumentation, development of assorted detectors of radiation, and improvement of computers (particularly additions to GEORGE—all of which should continue and grow). (A threefold increase in personnel is proposed for the next 5 years, dependent upon space.)

(3) Analytical chemistry. (Workload expected to increase by 50 percent; available space and personnel is inadequate at present.)

(4) Reactor operation: Present small staff expected to increase with responsibility for additional reactors. (At present, there are two operating reactors (CP–5 and EBWR); in 1960, three additional reactors (JANUS, JUGGERNAUT, and a fuel assay reactor), by 1963–65 a high flux research reactor and a solid state fast flux reactor.)

(5) Scientific and technical information: Effectiveness of staff depends upon convenience of information and adequate library facilities. (Central library required.)

(6) Supporting personnel. (Number of machinists must be proportionately increased; radiation protection personnel increase, other support people will increase but not in proportion to programmatic increases.)

SUMMARY OF LONG-RANGE PROGRAM SUBMITTED BY BROOKHAVEN NATIONAL LABORATORY [3]

(Section I of this summary sets forth highlights of the program as projected by the Laboratory, including tabular summaries of facility and personnel requirements and the Laboratory's view of future operating costs. Section II presents a more comprehensive summary of the program in outline form.)

Section I. Highlights

1. Physical sciences account for a little over half of the BNL research effort largely in basic investigations of various aspects of nuclear physics, chemistry, and metallurgy. The program has been built around major research machines, with nuclear physics and nuclear chemistry predominant; smaller efforts are involved with other chemistry research, solid state physics, metallurgy, and applied mathematics. Expansion of approximately 75 percent is proposed for the next half dozen years, of which nearly half is in the high-energy program as a result of the new 30 Bev. accelerator (AGS) and of improved facilities at the 3 Bev. cosmotron; additional emphasis will also be placed on the solid state physics and metallurgy programs and in radiation chemistry.

2. Life sciences research constitutes about one-fourth of the Laboratory program as measured in scientific effort, though relatively less in cost since it does not make major use of the large machines; of this effort approximately 40 percent is in biology, slightly more than 50 percent in medicine, and a little less than 10 percent in environmental research. Expansion of the total program of approximately 50 percent is proposed for the next 5 or 6 years, with a relatively larger increase in scientific effort in biology.

3. Reactor development and nuclear technology includes reactor physics, metallurgy and materials, liquid metal and fused salt technology, fuel cycle development, heat transfer, reactor evaluation and radiation applications. Present activities are based on existing principal scientific and engineering strengths in physics, metallurgy, chemistry, and chemical engineering. Expansion will emphasize materials and metallurgy; the effort in reactor physics, metallurgy, liquid metal, and fused salt technology and fuel cycle development will remain roughly of equal magnitude and the work in reactor evaluation and heat transfer together about half of that magnitude. Radiation application will be strengthened when the High Level Radiation Development Laboratory is completed.

4. Educational functions include participation in the research programs by thesis students and post doctoral research associates, a competitive summer student program, organized "courses" and seminars (presently very few in number), and the annual 10-week summer Laboratory program for AEC radiological fellows. Intensification of these educational processes is proposed.

5. *Facilities and personnel.*

(*a*) Facilities expansions and replacements of wartime mobilization structures totaling about $60 million are approximtely equally divided among the following categories:

(1) Specialized research and development facilities, including such items as additions to facilities including the AGS accelerator and maintenance and improvements to these facilities.

(2) Laboratory and office space.

(3) General service facilities.

(*b*) Personnel strength is proposed to be expanded from the present employment of slightly less than 2,000 to around 3,000 while contributions by research associates and visiting scientists will double or triple.

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[3] Dated February 1959.

TABLE I.—*Personnel summary*

	1959				1965			
	Staff scientists	Resident associates	Visiting scientists	Other staff	Staff scientists	Resident associates	Visiting scientists	Other staff
Physical sciences:								
Cosmotron	27	8	21	66	22	10	15	55
AGS	[1]	[1]	[1]	[1]	38	15	20	90
High-energy research	27	8	21	66	60	25	35	145
Nuclear structure	22	11	15	35	30	17	20	58
Solid-state physics and metallurgy	11	1	12	18	25	7	20	47
Chemistry	45	19	13	39	75	33	25	70
Applied mathematics	4	1	3	1	10	3	5	8
Total	109	40	64	159	200	85	105	328
Reactor development and nuclear technology:								
Reactor physics [2]	13	2	2	21	19	1	3	26
Reactor evaluation	2	------	1	4	4	------	1	5
Heat transfer [2]	3	------	1	4	4	------	2	7
Materials and metallurgy [2]	6	------	2	38	15	2	2	32
Liquid metal fuel chemistry and technology [2]	17	------	2	45	14	2	3	30
Fuel cycle development	11	------	1	21	18	------	4	37
Radioisotope and radiation source development	3	------	------	4	7	------	3	20
Total	55	2	9	137	81	5	18	157
Life sciences:								
Biological research	20	9	15	57	[3] 30	20	25	90
Medical research	26	17	10	122	35	20	20	175
Health physics metallurgical research and services	17	------	------	51	19	------	2	70
Total	63	26	25	230	[3] 84	40	47	335
Development and operation of devices and equipment:								
Accelerator development	5	------	1	2	10	------	3	10
Reactor development	3	1	------	5	5	------	2	9
Instrumentation devices and services	9	------	1	42	27	------	------	64
Mechanical engineering and design	9	------	------	38	25	------	------	72
Computer operations	6	------	1	17	20	------	------	30
60-inch cyclotron operations	------	------	------	9	------	------	------	9
Cosmotron operations	10	------	------	61	17	------	------	75
AGS	[4] 34	[4]	[4]	[4] 100	[5] 24	[5]	[5]	[5] 90
Graphite reactor operations	11	------	------	55	12	------	------	71
High flux beam reactor operations	------	------	------	------				
Total	87	1	3	329	140	------	5	430
Shared technical and skilled services	3	------	1	216	5	------	------	310
General administration and plant operation	------	------	------	577	------	------	------	725
Laboratory total	317	69	102	1,648	[3] 510	130	175	2,285

[1] See "Development of devices."
[2] LMFR project effort: 31 staff scientists, 2 resident associates, 7 visiting scientist man-years and 96 other staff in 1959 has been distributed among action noted. These do not include mechanical engineering and design effort included under "Development of devices and equipment."
[3] Revised Dec. 12, 1959.
[4] Construction.
[5] Operation.

TABLE II.—*Proposed buildings and facilities*

[Revised Dec. 12, 1959]

Facility	BNL program interest	AEC program interest	Estimated cost (in millions)		
			Specific facility	Acceleration and reactor addition	General plant
1961					
Chemistry laboratory	Chemistry	Research	$6.4		
Metallurgy addition	Nuclear engineering	Research (RD)	.7		
80-inch bubble chamber house	Physics	Research	1.7		
Contained critical facility	Nuclear engineering	Reactor development	.6		
Alpha (plutonium) facility	do	do	1.2		
Biology-pathogen free animal laboratory	Biology	Biomedical	1.2		
Biology-radiobotany facility	Biomedical	Research	1.3		
Quarters, visiting scientists	Laboratorywide	Sponsoring division	.6		
Library and technical information (Mod.)	do	do	.4		
Site utilities (steam, electric)	do	do	1.3		
Volatility studies laboratory	Nuclear engineering	Research			$0.3
General plant projects					1.0
Total, fiscal year 1961			15.4	$1.3	1.3
1962					
AGS—Particle separation system	Physics	Research	3.0		
AGS—Electric substation	do	do	.5		
Chemistry hot cells	Nuclear engineering	Reactor development	2.0		
Nuclear engineering building addition	do	Research and development (research).	2.0		
Instrumentation, health physics, ADD	Laboratorywide	Sponsoring division	3.0		
Administration lecture hall, cafeteria	do	do	2.6		
General plant projects					1.0
Total, fiscal year 1962			13.1	1.8	1.0
1963					
AGS—Experimental area	Physics	Research	3.0		
Shops and engineering building	Laboratory	Sponsoring division	3.5		
General plant projects					1.0
Total, fiscal year 1963			6.5	1.4	1.0

TABLE II.—*Proposed buildings and facilities*—Continued

[Revised Dec. 12, 1959]

Facility	BNL program interest	AEC program interest	Estimated cost (in millions)		
			Specific facility	Acceleration and reactor addition	General plant
1964					
Plant maintenance building	Laboratorywide	Sponsoring division	$2.1		
Site utilities	do	do	1.5		
General plant projects					$1.0
Total, fiscal year 1964			3.6	$2.0	1.0
After 1964					
Fuel cycle development laboratory	Nuclear engineering	Reactor development	2.0		
Biology additions	Biology	Biomedical	1.5		
General services building	Laboratorywide	Sponsoring division	1.4		
Quarters, visiting scientists	do	do	2.2		
Stock and warehouse, plant projects	do	do	2.0		
Total, all special facilities			47.7	(1)	(1)

[1] Annual requirement.

TABLE III.—*Cost projection*

	Program costs (in thousands)	
	1959	1965
Specific reactor projects	$3,603	[1]
Reactor systems R. & D.	525	
Fuel cycle development	445	
Subtotal	4,573	$5,200
Equipment	250	500
Reactor development, total	4,823	5,700
High energy physics	3,465	
Other physics	2,725	
Chemistry	2,335	
Metallurgy and solid-state physics	985	
Subtotal	9,510	19,800
Equipment:		
Program	1,000	4,600
General laboratory	600	600
Physical sciences, total	11,110	25,000
Radiation effects	1,410	
Beneficial applications	2,375	
Other	323	
Subtotal	4,108	[2] 6,000
Equipment	250	400
Biology and medical, total	4,358	[2] 6,400
Radioisotope and radiation source development	235	700
Equipment	45	100
Radioisotope and radiation source development, total	280	800
Research operations, subtotal	[2] 18,426	31,600
Equipment, subtotal	2,145	6,200
Research operations, total	[2] 20,571	[2] 37,900

[1] No specific reactor projects are shown in 1965. Should specific reactor projects require BNL support at that time, the work will be handled by the diversion of scientific and engineering staff and the addition of supporting help.
[2] Revised Dec. 12, 1959.
[3] Does not include costs for personnel assigned to AGS Construction.

Section II. Program summary

1. *General.*—

a. The National Laboratory concept is emphasized; Brookhaven serves as a center in which large machines and other specialized equipment are utilized by scientists from many institutions. BNL like other national laboratories must have strong support within the AEC, not only for operating funds, but also for the continuing provision of adequate physical plants and technical facilities.

b. Brookhaven's primary purposes are:

(1) To seek new knowledge in the nuclear sciences and related fields with emphasis on programs that require large-scale research tools which are beyond the scope of most individual institutions;

(2) To encourage appropriate use of its facilities by scientists of university, industrial, and other laboratories;

(3) To assist the AEC in the solution of specific problems which utilize the Laboratory's unique facilities or the special talents of its staff;

(4) To serve as an important auxiliary in the training of scientists and engineers and otherwise to assist in the dissemination of scientific and technical knowledge.

c. The general character of the scientific program, which covers a wide range of subjects in the physical and biological sciences and in engineering, can be broadly described under five major headings:

(1) Fundamental studies of atomic nuclei, the particles which constitute them, and the forces involved in their structure;

(2) The physical, chemical, and biological effects of nuclear radiation;

(3) The use of nuclear tools, such as neutrons, charged particles, gamma ray, and isotopic tracers, in all branches of scientific research;

(4) Research and development, not necessarily itself of a nuclear nature, directed at the problems of atomic energy development;

(5) The development of specific devices for use as research tools or in practical applications of atomic energy.

These common threads running across the various scientific disciplines lend a coherence and a mutuality of interest that enhance the entire program.

d. Related considerations: The Laboratory's future role has entailed consideration of many factors, among these the following:

(1) Nature of the scientific program:

(*a*) It is primarily intended to employ Laboratory facilities and staff skills in pursuance of scientific knowledge.

(*b*) The fundamental research programs at Brookhaven are defined only within broad frameworks agreed upon by the AEC and the Laboratory, the detailed development of the programs being largely determined by the abilities and interests of the staff.

(*c*) The program should be broadly based in many disciplines, exploiting thereby wide applicability of major facilities and benefiting from interrelationships between scientists in many fields and from many institutions; however, emphasis should be placed in a few fields of special competence within disciplines, taking care to preserve flexibility requisite to advanced research,

(2) Staff considerations: Facilities and technical information must be available to larger groups of scientists than can be present on the staff at any one time; consequently, flexible appointments are provided for "visiting" scientists and for graduate students pursuing doctoral theses. Continuity in research programs is achieved by a continuing staff of senior scientists with "permanent" tenure.

(3) External responsibilities: The most important educational function performed by the Laboratory is through participation in the research programs by thesis students, postdoctoral research associates and other young scientists; even more deliberately educational is the competitive summer student program. (Educational functions should be intensified.)

While Brookhaven performs many service functions, such as the irradiation of inert materials, etc., these are largely byproducts of the Laboratory's own program; this policy should continue and no appreciable effort should be made to provide facilities or staff purely for such service functions—those might better be provided elsewhere.

(4) Problems of management: No objective yardstick exists by which to measure effectiveness of research. Management problems are rendered more acute due to Government funding. (Commission can help by minimizing day-to-day monitoring in favor of judgment based on overall performance.)

(5) Future Laboratory size: There are no foreseeable limits on the amount of scientific and technical work to be done, but in Brookhaven's opinion there are definite limits on desirable Laboratory size. At some point a laboratory tends to become unwieldly, management begins to lose touch, and the cohesiveness of the laboratory and the invaluable cooperation existing in a smaller institution begins to suffer. (Optimum size for BNL, to be achieved over the next 8 or 10 years, would involve an increase in the research effort from 75 to 100 percent; the total Brookhaven staff proper would increase from its present level of slightly less than 2,000 to somewhat more than 3,000, not counting research associates and visiting scientists. Most of the growth would occur during the next half dozen years, with the 30 Bev. accelerator accounting for almost one-fourth increase, the new medical center for another 8 percent, and the remainder of the growth spread across the program.)

2. *The scientific program.*—Measured in terms of scientific and technical effort, slightly more than half of the scientific program is in the physical sciences; the remainder is about equally divided between reactor development and nuclear technology and life sciences research.

a. Physical sciences: Of a 75-percent anticipated growth in the next half dozen years, nearly half is proposed in the high-energy program as a result of the new 30 Bev. accelerator (AGS) and of improved facilities at the cosmotron. Additional emphasis will be placed on the solid state physics and metallurgy programs and in radiation chemistry.

(1) Nuclear and particle physics: High-energy physics constitutes approximately half of this effort while nuclear structure research and neutron physics contribute equally to the remainder.

The scientific staff in high-energy physics is expected to double; in the nuclear structure and neutron physics program effort will increase by 50 percent. The low-energy program is expected to move into new relatively unexplored fields through the acquisition of (1) the high flux beam research reactor and (2) the planned high intensity, intermediate energy cyclotron. The high-energy accelerator facilities will require expenditures of approximately $10 million over the next 4 or 5 years.

(2) Chemistry—basic: Approximately one-fourth of research effort in the physical sciences program is now in chemistry (expected to almost double in 5 to 6 years). There are existing strong programs in nuclear chemistry, radiation chemistry, chemistry and application of isotopes, and physical chemistry, molecular structure and solid state. In the future, radiation chemistry is expected to be given relatively more emphasis.

(3) Metallurgy and studies of the solid state: Program in the past has concentrated on use of neutrons in solid state, research on effects of irradiation on materials, and technology of liquid metals. Some diversification planned including electron irradiation of low-temperature targets and studies of materials at high temperatures under various conditions of irradiation. Expansion and diversification of personnel are anticipated, increasing the now relatively small Brookhaven staff by threefold while the contributions from research associates and visitors are expected only to double.

(4) Mathematics: This recently started program is intended to explore specific mathematical areas to support the applied needs of other BNL programs and the mathematical community at large. Construction of a large computer (Merlin) is just about finished. Start up of this device and relative youth of mathematics program call for planned expansion by somewhat more than a factor of 2.

b. Reactor development and nuclear technology: Reactor development and nuclear technology programs presently constitute one-quarter of Brookhaven's research and development effort. The liquid metal fuel reactor development program was discontinued in fiscal year 1960. Future work calls for broadening of the program. Effort in reactor physics, metallurgy, liquid metal and fused salt technology and fuel cycle development will be roughly of equal magnitude and will account for about 85 percent of the total. The remainder of the program effort will be in reactor evaluation, heat transfer, and radiation science and radioisotope development.

(In this future prediction, Brookhaven has assumed that the several general nuclear engineering research activities will progress in accordance with the prediction shown in tables I and III which assume no specific reactor projects in 1965. If in the future it should be decided that a particular large special reactor project should be carried out at BNL, it would be necessary, because of manpower limitations, to divert scientific personnel from the general research and development effort and temporarily to increase the total departmental effort in the professional and technician categories.)

(1) Reactor physics: Some expansion in overall program.

(2) Metallurgy and materials: Substantial expansion is expected in reactor metallurgy effort.

(3) Liquid metal and fused salt chemistry and technology: Continue program of research on fundamental chemistry.

(4) Fuel cycle development: Some expansion of effort.

(5) Heat transfer: Extend program to include both experimental and analytical investigations.

(6) Reactor evaluation: Continue on present studies and on new proposals for reactors and reactor components.

(7) Radiation science and radioisotope development: Expand effort, especially in anticipation of more high level radiation source development. Construction of the High Level Radiation Development Laboratory has been authorized.

c. Life sciences: This program constitutes about one-fourth of the Laboratory program; approximately 40 percent is in biology, slightly more than 50 percent in medicine, and approximately 10 percent in environmental research. It is expected to grow approximately 50 percent, with biology increasing somewhat more than the other disciplines.

(1) Biology: Work is directed toward the effects of irradiation on biological systems and the development of nuclear techniques for biology. These include genetics, radiobiology, molecular biology, mammalian physiology and cellular physiology. Biological effort expected to increase about 50 percent in continuing BNL staff and 100 percent in research associates and visitors.

(2) Medicine: Present work concentrates on nuclear medicine and includes activities such as neutron capture therapy; study of trace metals with special emphasis on central nervous system diseases; radioactive elements in man, hematology of radiation; study of radiation effects on immunity and allergy; study of cancer including use of neutron therapy and radioactively labeled compounds; investigation of carbohydrate, protein, and nitrogen metabolism; use of radioactive isotopes for prediction of lifespan; functions and progeny. Medical program expected to reach equilibrium size within next few years.

(3) Environmental research: Involves health physics research and instrument development, as well as a small program in meteorology. Only a moderate increase in research activity expected.

3. *Operations and facilities.*—

a. Operations: The Laboratory's principal operating cost factor is labor—75 percent, excluding capital equipment and large procurements for special projects. Requirements for capital equipment will continue to be from 7 to 10 percent of operating costs, with the exception of equipment costs for the program sponsored by the Research Division where such costs are likely to be as high as 25 percent of the operating costs.

Operating costs proper for the programs projected will increase from $18,500,000 in 1959 to $32 million in 1965, exclusive of capital equipment costs; largest single increase is in the physical research program and is due principally to the activation of the high energy research program with the AGS.

Program projections indicate a cost change of about $1 million or slightly less than 25 percent for the Reactor Development Division, for the period 1959 to 1965.

A cost change of almost $14 million (125 percent) is predicted for the physical sciences program for reasons noted above. For the Bio-Med Division, the increase is about $2,500,000, or slightly less than 50 percent of present cost.

Work in radioisotopes and radiation source development, initiated in fiscal year 1959, is expected to increase severalfold.

b. Facilities: The building program at Brookhaven is far behind in meeting the existing needs of the research programs. The most urgent need of BNL today is the provision of sufficient and suitable space for carrying out the scientific program including the associated supporting services. While major research machines and some laboratory facilities have been built, a large number of mobilization type buildings of temporary construction, which were a part of Camp Upton, are still in use. Many of these buildings are now in deplorable condition and adversely affect the operation of the Laboratory. Their replacement by suitable buildings is long overdue.

SUMMARY OF LONG-RANGE PROGRAM SUBMITTED BY OAK RIDGE NATIONAL LABORATORY [8]

Section I. Highlights

1. The basic orientation of ORNL toward chemical technology and reactor development began with its original mission as a pilot plant for the development of plutonium extraction processes for employment at Hanford. Subsequently, the Laboratory has grown by absorption of the wartime electromagnetic development laboratory and by assignment of major project responsibilities such as the ANP project and the gas-cooled reactor project. As a result, the Laboratory's interests and skills have continually widened until ORNL is now involved in research and development on most of the nonweapon activities of the AEC.

The Laboratory's mission is primarily an applied one; approximately three-fourths of the budget is devoted to applied research, development, and production, of which the two largest areas are reactor development and chemical pro-

[8] Dated June 3, 1959.

cessing. The approach of ORNL in these fields reflects the Laboratory's chemical tradition. Thus, in reactors, ORNL is the center for those systems such as fuel thermal breeders which primarily involve chemical engineering techniques. In addition, the Laboratory exploits its skills in high-temperature materials, acquired during ANP days, to pursue civilian gas-cooled, maritime, and packaged power reactors. The Laboratory is the country's central establishment for producing isotopes.

In the near future the Laboratory will be a center for the reprocessing of spent fuel elements from the power demonstration reactors. Because of experience in ion physics and electrical engineering which ORNL staff acquired during the development of the Y–12 electromagnetic separation process, the Laboratory has engaged heavily in the controlled thermonuclear project.

2. *Reactor development.*—Delineation of the Laboratory's mission in reactor development has always been a more severe problem for the Laboratory than delineation of its mission in other applied fields. The Laboratory believes that a major administrative problem has been solved with the clear statement of ORNL's long-term mission in reactor development, as follows:

a. Thermal breeding: ORNL has been assigned the responsibility for developing the thermal breeder systems. Although considerable progress has been made in the development of the aqueous homogeneous and the molten salt systems, the solution of several technical problems, demonstration of the degree of operating reliability essential for economic power costs, and actual attainment of breeding; remain. This is therefore the long-range reactor development of the laboratory. ORNL will continue to pursue the two fluid systems—molten salt and aqueous homogeneous—with the hope of building a small prototype of each by the middle 1960's. One type will be selected for construction, planned for fiscal year 1968, of a large prototype; work on the other type will be reduced or stopped.

b. Gas-cooled reactor: ORNL has major responsibility in the gas-cooled reactor program; the responsibility includes general technical guidance for the 85-megawatt reactor to be built in Oak Ridge, and continued research aimed at improving the performance of gas-cooled reactors. As part of the short range reactor program, ORNL will concentrate mostly on the gas-cooled systems. The next 10 years will very probably see at least one additional, very advanced, gas-cooled reactor built under the Laboratory's supervision.

c. Technical assistance: The Laboratory provides technical advisory service on specific reactor problems as well as broad questions of concern to the overall reactor development program. The Laboratory will continue to serve as a source of reliable and unbiased advice to the Commission in many of its reactor programs.

d. General reactor development: This work includes research and development in metallurgy, chemistry, and solid state physics aimed at improving reactor fuel elements and construction materials; in electronics; to improve reactor control and safety systems; and, in engineering, to increase the knowledge of heat transfer and hydrodynamics, and to improve components and evaluate the corrosive behavior of materials under reactor conditions. Work will be continued in these fields and will be oriented partly in direct support of the major ORNL reactor programs, and partly in support of the various projects throughout the Commission.

e. The Laboratory management stresses that firm adherence to this mission over the next 10 years will, more than any other single action of the Commission, enable the Laboratory to steer a sensible and responsible course over the next decade.

3. Chemical processing activities will be devoted to adaptation of processes to the fuels from specific reactors and to exploration of promising new approaches. The experience which ORNL has acquired in the fabrication of fuel elements for test reactors and fundamental information from metallurgical and radiation effects research will be applied to the problem of producing higher performance fuel elements. Programs to devise and test safe and economical methods for disposal of radioactive wastes or for utilization of byproduct wastes have been initiated and will continue.

4. Controlled thermonuclear program is based primarily on continuous high-energy injection into a containing magnetic field. The future magnitude and distribution of effort among the major categories in this program should be determined by the imminence of a practical solution of the thermonuclear power program. The Laboratory's approach to achieving an ultimate energy source

should develop naturally over the next decade. It will probably take about 5 years to bring the science of plasma to a point where it will be possible to assess realistically the outlook for fusion power. The projections for Sherwood must therefore be considered very tentative and almost sure to be modified as more information is acquired.

5. *Physical science research.*—

a. Physics: A large fraction concerns reactions of neutrons, especially those pertinent to reactor development or the utilization of neutrons as tools for research. The Laboratory should continue to pursue a broadly based fundamental program coupled with special emphasis upon neutron physics and fission physics because of their connection with fission power. The Laboratory will venture somewhat further into very high-energy physics but will do so carefully to avoid loss of its ability to work in the low-energy field.

b. Chemistry is concerned with the chemistry of the fission process and the fission products; research to determine chemical properties and reactions in aqueous and nonaqueous media has increased, along with the growth of the reactor development program. Work will continue with shifts in emphasis as needed to shore up the applied programs. The addition of the ORIC (Oak Ridge relativistic isochronous cyclotron) and the HFIR (high flux isotope reactor) should stimulate work in heavy element chemistry, and in this field a small expansion is likely.

c. Metallurgy and solid state physics is concentrated upon obtaining a knowledge or understanding of the fundamental properties and reactions of metals, ceramics, semiconductors, and organic materials, primarily under conditions encountered in reactors.

6. Life science research problems studied are those principally concerned with the use of nuclear energy, the investigation of the biological effects of radiation and the development of means to alleviate or counteract such effects. Major problems in biophysics include the development of methods to measure radiation dosage accurately, to establish permissible radiation exposure levels, and to determine the biological course of radioactive materials released into the environment. The biological sciences, including health physics, ought to expand significantly over the next 10 years.

7. *Education.*—Besides making its facilities available to properly qualified faculty members, the Laboratory provides training in specialized fields including reactor supervision, nuclear hazards, health evaluation, physics, and on-the-job training for technical personnel from private industry. An extension of the educational activities at ORNL can be expected.

8. Isotope research and development will be directed primarily by the needs of the isotope production program. Continuing objectives are to increase the purity of all isotope preparations, lower costs, and to develop methods for converting radioisotopes into any desired chemical or physical form. It is expected that the number of personnel will increase in both the radioisotope and stable isotope programs.

9. *Facilities.*—All the foregoing plans and activities require facilities. The present building program, when completed, should supply ORNL with most of the general-purpose laboratories it will need, at least over the next decade. Facilities for high-level radiation work are another matter, and additional specialized laboratories of this type will be needed.

Section II. Program summary

1. *Problems of administration.*—

a. Delineation of ORNL's reactor mission has always been a more severe problem than delineation of its mission in other fields. The Laboratory believes that a major administrative problem has been solved with the clear statement of ORNL's long-term mission in reactor development, and that, by comparison, other problems over the next decade will present relatively little difficulty.

b. As to whether ORNL should build and operate prototype reactors the Laboratory will continue to insist on its prerogative to build and to operate experimental devices of any size if such are needed to carry out the Laboratory's technical responsibilities to the Commission.

c. The Laboratory has no desire to expand significantly except in some areas of biology and chemistry. On the other hand, the Laboratory has no important objection to expanding at an expected rate of 20 percent in 5 years. Such expansion is a rather natural growth which comes with maturation of various

projects. The technique of decentralized management is sufficiently well developed at ORNL to allow such expansion to be taken in stride.

d. Maturing of staff is a problem shared by most of the atomic energy laboratories. The modal age of the technical staff at ORNL is now about 34; by 1969 it may be as high as 44. It is axiomatic that a research institution cannot maintain its vitality if its staff grows old and the management of ORNL has always been cognizant of this fact and problem. The situation will require serious attention and examination by laboratory management in the future.

c. The general-purpose facilities (laboratory, research reactors, shops, etc.) which are in being, under construction, or which are included in the 1960 budget submission are probably adequate for the next decade with the exceptions listed in the complete report.

2. *Scientific and technical long-range proposals.*—

a. Reactor development:

(1) Long-range reactor development—Thorium utilization: This responsibility is being undertaken in the broadest sense and will involve frequent reevaluation of the importance of conversion rates, doubling time, and inventory of fissionable and fertile material on the usefulness of reactors in supplying the world's energy requirements from thorium. All types of reactors that have potential utility in this field will be analyzed to determine their relative merits. The most promising types will receive sufficient experimental work to ascertain whether they can attain their theoretical promise. One or more types will be developed through the reactor prototype stage to provide the technology required for further exploitation on an industrial scale. Reactor development activities are presently concerned entirely with the aqueous homogeneous and molten salt reactors. Because both types have exceptional promise, they will be developed concurrently through completion of the reactor experiment stage. At that time one type will be chosen to be pursued through the large prototype stage; work on the other type would then be reduced to some low level or stopped. Beginning of construction is planned for about fiscal year 1968 and operation begun in fiscal year 1971 or sooner. The major ORNL participation in the thorium breeder program will be completed with experimental operation of the prototype.

(2) Short-range reactor development: The Laboratory's program of short-range reactor development is intended to reflect directly the Government's intent to utilize the development of nuclear power as a vehicle of national policy. The Laboratory's role in the shorter range reactor program is twofold: continued responsibility for research leading to high-performance gas-cooled power reactors and technical advisory service to the AEC on broad questions of concern to the overall program as well as on specific reactor systems. The Laboratory expects to build other experimental reactors and reactor cores beyond the GCR with the principal basis being new and improved fuel elements. Other possible areas of interest include the direct conversion of radiation to electricity, use of nuclear power in space exploration, and possible attention to areas of applied research and development associated with nuclear energy.

b. Chemical processing development: ORNL has been strong in radiochemical separations and has become a recognized center for process development. With most of the process development demands for production now satisfied, major programs are being and will continue to be directed to the industrial utilization of nuclear energy and in the industrial utilization of radioisotopes and radiation. ORNL has facilities now available, planned and approved, or proposed, in which to carry out radiochemical separations at the highest activity levels on a significant engineering scale. The objectives of the radiochemical process development and demonstration programs are to develop radiochemical separations techniques which will make it possible to reprocess any power reactor fuel in a single multipurpose chemical plant. Allied programs that should be sustained as important concern development of effective radiochemical waste treatment procedures and development of safe containment and disposal for high-level and low-level contaminated wastes in gaseous, liquid, or solid forms. To apply existing and new knowledge in the future to the problems of either "commercial" utilization or to very unique applications will require the expansion of fundamental knowledge in both process chemistry and engineering. The organization of the chemical development and basic engineering studies needs to be established under longer range programmatic studies rather than supported by projects with limited and sometimes transient objectives. The expansion of fundamental knowledge in process chemistry and in applied reactor chemistry

will naturally lead to the establishment of more fundamental and applied research subcontracts with universities and qualified industrial research and development organizations.

c. Controlled thermonuclear program: The ORNL program is based primarily on continuous high-energy injection into a containing magnetic field. To pursue this program there are three major activities: First, the development of experimental machines; second, the system development necessary for these machines; and third, a program of basic research in plasma physics in order to understand the results of the experiments and to discover new avenues of approach to thermonuclear power. These three major activities are at present roughly equally balanced in support. The future magnitude and distribution of effort among these activities should be determined by the imminence of a practical solution to the thermonuclear power problem. The Laboratory's approach to achieving an ultimate energy source should develop naturally over the next decade. It will probably take about 5 years to bring the science of plasma to a point where it will be possible to assess realistically the outlook for fusion power. The projections for Sherwood must therefore be considered very tentative and almost sure to be modified as more information is acquired.

d. Physical science research:

(1) Physics, instrumentation and mathematics: In the nuclear sciences, the Laboratory pursues and should continue to pursue a broadly based fundamental program coupled with special emphasis upon neutron physics and fission physics because of their connection with fission power. Instrumentation and applied mathematics are both laboratorywide in their import, partly geared as service organizations for the research divisions, but both also encouraging originality in their own right.

(*a*) Physics: To explore systematically all phases of physics which are related to nuclear technology. As the needs of the research program become apparent in the future, new tools will be required which will make it feasible to extend the basic knowledge in directions indicated by the needs. Future plans for research with the new ORIC (Oak Ridge relativistic isochronous cyclotron) are difficult to predict; however, it is certain that experiments will be extended to higher energies and produce important results concerning knowledge of the atomic nucleus. To make progress in the understanding of physical phenomena, it is necessary to apply techniques ranging from low-temperature solid state physics to ultra-high-energy particle physics. The ORNL has entered the high energy field only recently. In order to broaden the basis of the investigation of nuclear forces and nuclear structure, it is expected to increase the effort in the field of ultra-high-energy physics in the future. This will prepare the Laboratory for efficient utilization of the southern regional accelerator when it becomes available.

(*b*) Neutron physics: Information basic to an understanding of reactor operation is that dealing with processes of neutron production and absorption and measurement of the basic as well as adjunct parameters. Valid subjects for future study include criticality experiments, detailed neutron transport behavior, and spectral variations in the vicinity of discontinuities in reactors. All the experimental effort is being aimed at the possible development of a well-rounded theory for reliable predictions of critical mass, fission distributions, etc., so that one could ultimately dispense with much of the critical experimentation. Hence, analytical approaches to reactor analysis will be pursued and within 10 years should be capable of affording a quantitative understanding of most phenomena of neutron production, transport, and absorption.

(*c*) Instrumentation: Since the atomic energy program is so closely linked with instrumentation and control, each of the national laboratories will always have a large group of scientists and engineers devoted to this activity. The report lists 23 examples of future projects in the field of instrumentation which it hopes to examine during the next 10 years. In order to carry out the objectives of such a program, an increase of up to 50 people will be required.

(*d*) Mathematics: The three broad fields of programing theory, numerical analysis, and classical analysis will require increased attention and the staff will increase more rapidly, relatively, than the Laboratory has as a whole.

(2) Chemistry: Research is organized into four separate divisions; the work of the Chemical Technology Division was described under section 3b on chemical process development; this section will be concerned with the remaining divisions which comprise 60 percent of the scientific staff in chemistry. Basic chemical researches are conducted in six areas:

(*a*) Radiation chemistry: Recently increased attention has been given to the radiation chemistry of gases, where new advances seem possible, and to the radiation chemistry of molten salts, of organic compounds, and of catalytic changes at solid surfaces.

(*b*) Nuclear chemistry: Present studies concern the properties of radioactive nuclei, nuclear reactions, and the applications of these two topics to other fields. New efforts will be made to study the radiations emitted in the decay of the short-lived fission products because of their relevance to the shielding and chemical processing problems characteristic of certain reactors.

(*c*) Isotope chemistry: The two principal activities concern the seperation of isotopes of the light elements and the use of isotopes for basic work in organic chemistry. This work will continue.

(*d*) Inorganic chemistry: The properties of fission products technetium and promethium have been studied because of the possibility of extracting them from radiochemical plant wastes. Both elements are of importance because of high fission yields, long half-lives, and large thermoneutron absorption cross-sections. Work will continue.

(*e*) Physical chemistry: Activities include significant efforts in two areas of high-temperature chemistry; molten salts and aqueous solutions. Other investigations include ion exchangers, the chemistry of corrosion, and thermochemical measurements on various compounds.

(*f*) Chemical physics: Work will continue with the application of neutron X-ray diffraction techniques for the determination of chemical structure, with microwave spectroscopy for measurements of the polarity of chemical bonds and for studies in radiation chemistry and with the use of molecular beams for the elucidation of the kinetics of chemical reactions.

(3) Metallurgy and solid state:

(*a*) Metallurgy: The basic research programs in metallurgy and solid state physics at the laboratory have as a common point of departure the investigation of the relationship between the structures of solids and their mechanical, electrical, thermal, and other important physical properties. In metallurgy, work is conducted with unirradiated metals and ceramics, whereas in solid state physics efforts are devoted to achieving an understanding of the interactions of neutrons, charged particles, and electromagnetic radiations with all types of solids, including metals, semiconductors, refractories, ionic and covalently bonded crystals and plastics. The program in metallurgy has been devoted to such items as physical metallurgy, micro strains in crystals, high-temperature reactions, ceramics, and metal surface studies. Future efforts will concern ceramics and cermets, basic studies on the oxidation of pure metals in gases, and continued studies supporting development of superior alloys for reactor use.

(*b*) Solid state physics: Directed almost wholly to the measurement and elucidation of radiation effects in solids and to the effects of radiation on the oxidation of metals. The next decade should witness important advances in solid state physics.

e. Life science research:

(1) Biology: Basic mission is the study of radiation effects in biological systems in an effort to design means of protection against radiation damage and counteracting damage after radiation has been absorbed. Work will continue to be concentrated along specific lines of basic genetical and cytological research and will not be dispersed more than is absolutely essential. The criteria of radiation damage being developed in the Division may well form a basis for trying to find an answer to the question of whether there is a threshold for radiation-induced malignancies (leukemia), for studying the effects of strontium 90, and other problems. It should be seriously considered at this time whether or not the laboratory should get involved in these studies which may well grow out of investigations going on at ORNL now. Such studies will require a large outlay of funds and should be carried on for at least 20 years for significant results.

Serious consideration should also be given to the need for trained botanists. From the long-range viewpoint, it would be wise to build up a strong ORNL

plant science group since many basic problems can be investigated much better on plant material than in animals.

(*a*) Cytology and genetics: Emphasis is on basic studies of cellular structure and function, and of the action of radiation on the cell and especially on the genetic apparatus. This program will continue at the present high level.

(*b*) Mammalian genetics and development: Basic questions about the nature of the mutation process require that many new experiments be performed to explore the exact nature of the relation between radiation intensity and mutation rate. Recent developments are significant to consideration of the genetic effects of fallout and occupational exposures. The present level of activity will continue although new projects will be initiated as certain major studies are completed.

(*c*) Microbial protection and recovery: Concerned with understanding the sequence of events—physical, chemical and biochemical—that follow the initial energy absorption process to the irreversible establishment of biological damage in material at the cell level. Work will be devoted to the role of protective agents and conditions, repair and other factors which may influence the effect of radiation more or less over the spectrum of linear energy transfer.

(*d*) Mammalian recovery: Concerned with treatment of lethal total body radiation exposure. Future projects to include: the possibility of transplanting tissues by way of bloodstream and other unusual routes, cell preservation studies aimed at growing functional cells and tissue culture, studies of the normal histology and anatomy of the lymphatic system, and initiation of work on the problem of treating higher levels of radiation damage.

(*e*) Pathology-physiology: These studies have been concerned with the pathogenesis of early and delayed somatic radiation effects in mammals with emphasis on the induction of leukemia and neoplasia. This program will be expanded to encompass the life shortening and carcinogenic effects in mice of chronic low-level radiation.

(*f*) Cell physiology: The major objective of this project is the determination of the molecular basis of cell function. The findings will provide a background to facilitate determination of the effects of radiation and other insults on cellular function. No major increase in the program is anticipated.

(*g*) Biophysics: The biophysics research is concerned with the understanding of the basic primary physical and chemical events which underlie and govern the action of radiation in biological systems. Significant advances have been made by the application of electron spin resonance methods to biological materials. It is anticipated that these studies will be expanded in conjunction with an overall increase in the Commission-supported effort in biophysics and bioenergetics.

(*h*) Radiation immunology: These investigations are concerned with the fundamental immunological aspects of bone marrow and other tissue transplantation, and with fundamental immunological investigations. A modest expansion is planned with emphasis on the immunogenetic aspect of the problem.

(*i*) Biochemistry: The biochemistry projects at the Oak Ridge National Laboratory have been concerned with three major problems: intermediary metabolism in bacteria and plants, nucleic acid biochemistry, and protein synthesis. Considerable expansion is planned with emphasis on the interrelationships and genetic control of nucleic acid and protein biosynthesis, biochemical studies of gene action, and studies of cellular differentiation at the molecular level.

(2) Health physics: Health physics must continue to develop as the nuclear technologies grow, particularly in industry. Basic to the science are the processes of the interactions of radiation with matter; work in this field, both theoretical and experimental, must continue. Also basic is good dosimetry; increasing emphasis will be placed on further research and development of these techniques.

(3) Waste disposal: The long-range objectives of the waste disposal and ecological research programs are: (1) to develop better and cheaper methods for the ultimate disposal of liquid and solid wastes in geologic formations isolated from the living environment, (2) to evaluate dilution and concentration factors in the environment which determine the degree of treatment required before low-level wastes are released to the ground or to surface waterways,

(3) to develop more efficient methods for the treatment of large volume, low-level wastes, (4) to obtain quantitative information on the movement and rates of biogeochemical cycling of Sr 90, Cs 137, and other fission products in a variety of forest and fresh-water habitats.

f. Education: Besides making its facilities available to properly qualified faculty members, the laboratory provides training in specialized fields including reactor supervision, nuclear hazards evaluations, health physics, and on-the-job training for technical personnel from private industry. An extension of the educational activities at ORNL can be expected.

g. Isotope research and production: Isotope research and development will be directed primarily by the needs of the isotope production program. Continuing objectives are to increase the purity of all isotope preparations, lower costs, and to develop methods for converting radioisotopes into any desired chemical or physical form. It is expected that the number of personnel will increase in both the radioisotope and stable isotope programs. Private reactor operation and associated radioisotope production will have a great influence on this program during the next 10 years. Inasmuch as industry will tend to make only those radioisotopes which can be profitably produced on a large scale, the ORNL radioisotope group will concentrate on making those materials available that others cannot or do not produce.

h. Facilities: All the foregoing plans and activities require facilities. The present building program, when completed, should supply ORNL with most of the general-purpose laboratories it will need, at least over the next decade. Additional facilities which will be required include high-radiation level laboratory space, additional chemical process development hot cells in various locations, a 10 MEV Van de Graaff accelerator to extend the nuclear physics program, a hot laboratory for isotope separation of radioactive nuclides, and additional laboratory space for biology work in the present structure at Y–12 for increased work in radiation protection research, biochemistry, and plant and animal physiology.

SUMMARY OF LONG RANGE PROGRAM SUBMITTED BY AMES LABORATORY[4]

Section I. Highlights

1. Physical science research at Ames has, since its inception, been directed toward metallurgy, with primary emphasis on the development of methods for producing high-purity substances and evaluating properties of these materials. No major changes in the overall objectives are envisioned for the next 5-year period. The authorized expansion of physical facilities will enhance the laboratory's ability to produce quantities of highly pure metals and alloys and to evaluate the nuclear properties of solids.

2. Educational opportunities, made possible by the close relationship between Ames Laboratory and Iowa State University, have enabled about 30 metallurgists and about 400 other scientists and engineers to receive advanced graduate training at the laboratory. Over a hundred of these former students are now employed by the other AEC laboratories and contractors.

Section II. Individual Ames Laboratory programs

1. The primary purposes of Ames are: (1) to conduct an expanding fundamental research program on atomic energy materials, with emphasis on metallurgy; and (2) to encourage the training of scientists and engineers, particularly in the fields of solid state physics, chemistry, metallurgy, and ceramics.

2. The general character of the scientific program has confined itself to two major areas:

(*a*) Development of methods for producing uranium, thorium, yttrium and the rare earths; and

(*b*) Evaluation of the chemical, physical, engineering, and nuclear properties of these and other metals and alloys utilized in the atomic energy program.

3. *Research programs (1960–65).*—

(*a*) Reactor development research programs will concentrate on metals such as thorium and its alloys, yttrium and its alloys, rare-earth metals and their alloys, properties of metals and ceramics at temperatures above 1,000° C., effect of nonmetallic impurities on metal properties, the measurement of engineering properties such as fatigue and corrosion rate at relatively high temperatures, new

[4] Dated July 1959.

pyroprocessing techniques and the measurement of physical properties at high temperatures.

(*b*) Work in high energy physics will continue to use nuclear emulsions, although it may be supplemented by the use of solid luminescence chambers.

(*c*) Work in nuclear structure and neutron physics will continue to take advatage of the unique characteristics of the Iowa State synchrotron.

(*d*) Chemistry research will consist of fundamental studies on the mechanism of various separation processes such as ion exchange, solvent extraction and sublimation, as well as the development of analytical and spectrochemical analytical methods.

(*e*) Future work in metallurgy and solid state physics will take advantage of new techniques, such as de Haas-van Alphen effect measurements on single crystals, the use of ionic crystals, the measurement of magneto-acoustic effects on metallic crystals at 1° absolute, high-pressure work and the measurement of fundamental properties that will help determine the real nature of the solid state.

4. *Additional facilities (1960–65).*—A new metals development building will be available in late 1960 with 47,000 square feet of space. This will alleviate a crowded condition brought about by carrying out production work in an area designed for smaller scale work.

The authorized Ames Laboratory research reactor will round out the 5-year facility requirements and permit some reassignments to improve the space situation.

5. *Manpower requirements (1960–65).*—The successful performance of Ames' basic research programs requires that a nucleus of competent and experienced group leaders and specialists in the various fields essential to the atomic energy program be maintained.

The availability of additional facilities will require additional service, maintenance, and supervisory personnel.

An orderly growth in personnel by the Laboratory as a whole is expected, with personnel being added in those areas that are most productive and whose research efforts are most in line with the AEC's mission in the next few years. It is expected that six new research groups will be needed in the next 5 years. Five would do fundamental basic research and one, applied engineering research related to the reactor or to the pure metals program. The actual number will be dependent upon the availability of qualified personnel and funds.

LONG-RANGE PROGRAMS SUBMITTED BY LAWRENCE RADIATION LABORATORY[5]

General comment

In reply to your letter of July 7, 1959, regarding the Joint Committee's interest in the role of the AEC laboratories, we have prepared, as requested, two answers—one for the Berkeley site and one for the Livermore site of the Lawrence Radiation Laboratory.

However, I wish to make several points that relate to the role that the Laboratory can and must play when considered as a whole, and as a part of the University of California. These points particularly bear on the ability of the Laboratory to assist in the national needs and in the needs of the Atomic Energy Commission.

The staff and the facilities of the Laboratory which the Commission has supported so generously provide a strong scientific and technical capability unique within the Commission. The two major sites of the Laboratory had, in the beginning, a high degree of connection, the Livermore site being a direct offshoot of the Berkeley site. This connection, while less today, is still considerable, particularly in the administrative and service groups. The degree of interrelation between the scientific groups varies among the different fields of interest. With Livermore acquiring more powerful computers, and with Berkeley planning new programs of more direct interest to Livermore, such as the inorganic materials program, this interrelation can be expected to increase and to be of great value in the combined activities of the two sites.

The association with the university helps to keep the Laboratory scientifically alive, and enables Laboratory scientists to have the stimulation of contact with the coming generation, the students.

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[5] Sept. 17, 1959.

From these factors has come the ability to make substantial basic and applied research contributions in many fields and the ability to train scientists and engineers and thus increase the Nation's supply of technical people.

Since the Laboratory is primarily concerned with nuclear energy aspects, it is easy to forget that people trained in nuclear science have made major contributions in the national interest in other fields. Many outstanding examples occur in the missile program, the space program, and military electronics. Similarly, many of the Laboratory's developments in techniques, processes, and materials have applications which are far more important and of widespread use than their initial purpose.

The value of the Laboratory to the needs of the Nation and the AEC lies, therefore, in its existence as a vital, living organization—doing research, training people, and improving the Nation's present standing in the fields of its major activities.

SUMMARY OF LONG RANGE PROGRAM SUBMITTED BY LAWRENCE RADIATION LABORATORY—BERKELEY [6]

Section I. Highlights

1. Primarily a basic science laboratory. Its scientific program covers physics, chemistry, biology, and medicine, and miscellaneous smaller projects. As part of the University of California and located on its Berkeley campus, the Laboratory benefits from the close ties to the academic world. It has a natural interest in graduate training.

2. The physics research program represents about 55 percent of the effort, and concentrates almost entirely on high energy physics. The bevatron (a 6.2 Bev proton synchrotron) has been the major accelerator in the antinucleon field and has a large experimental program in full swing. One of the most important facilities used with it is the 72-inch liquid hydrogen bubble chamber. In the future the Laboratory will continue to perform an active experimental program with the modified and improved bevatron and will actively work on an accelerator development program to open up higher energy and current ranges. Substantial expansion is envisioned.

3. The chemistry research program uses some 22 percent of the Laboratory's effort. The particle accelerators furnish materials for research as well as the tools with which to work. The 60-inch cyclotron and the heavy ion linear accelerator are the principal machines used in transplutonium element research and isotope studies in general. The future chemistry program will utilize accelerators to an increasing extent. An 88-inch high current cyclotron is being built. Expansion in scope and effort is anticipated.

4. The biology and medicine program represents about 15 percent of the scientific effort at Berkeley. This includes the work of a bio-organic chemistry group. The program includes cellular and subcellular radiobiology, studies of the hemopoietic system, biomedical studies with cyclotron beams, and other investigations of biomedical interest. A development program of novel and sophisticated instrumentation and techniques is continuing. Some expansion is expected.

5. A small controlled thermonuclear research project and various other smaller projects account for the remaining 8 percent of the Laboratory's effort.

6. An inorganic materials program, to be interdisciplinary in nature, is expected to be launched in the near future. This work is of importance to reactor research, nuclear propulsion, controlled thermonuclear reactions, and space and missile technology. Initially, work will be in high-temperature chemistry, physical chemistry of the solid state, metallurgy and ceramics, and general inorganic and physical chemistry. As many as 600 men may ultimately be required on this program.

7. *Facilities and personnel.*—The size of the Laboratory should be governed by the research program. However, limitations may be imposed on size or administrative considerations.

The administrative problems of size can be solved by proper organization and delegation of responsibility. The limitations imposed by the site have been a problem at Berkeley. However, as a result of the recent consideration of the university's master plan, building sites in the Strawberry Canyon area will be made available to the Laboratory when needed. This area is between the campus proper and the southern entrance to the Laboratory. It will permit the Laboratory to double in size if necessary.

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[6] Dated September 1959.

The number of people at Berkeley has increased from 1,100 to 2,200 in the last 10 years. During this time it supplied people for the MTA effort, the large diagnostic experiment at Greenhouse, and started the Livermore Laboratory. There are many reasons for believing that the Laboratory should again double in size during the next 10 years.

This is partly due to the fact that the experiments, especially in high-energy physics, have become more complex. The simpler experiments have been done. The equipment requirements and support facilities and people have increased with the size of the accelerators. In addition, the number of experimental areas has increased resulting in better utilization of the machines. This increases the number of research groups which in turn has an impact on the support required.

New or enlarged areas of research, such as the recently proposed inorganic materials program, will add to the size of the Laboratory. In 10 years, this alone could add 600 people to the staff.

The size of the University of California at Berkeley is expected to increase from 20,000 to 40,000 in the next 10 years. We can expect that the number of graduate students and postdoctorals who wish to work in and can contribute to the work of the Laboratory will also double.

Requirements for equipment and facilities must keep pace with the research program and the size of the staff. In addition, many of our facilities are wartime buildings which have outlived their usefulness. Some are in the way of the orderly development of the site. Substantial capital investments will therefore be required to correct this situation.

Operating funds will also have to grow substantially. It is estimated that it will have to be 2½ to 3 times our present level 10 years from now.

Section II. Program summary

1. Physics: The Lawrence Radiation Laboratory is one of the major centers of the high-energy physics in the world. The two accelerators, the bevatron and the 184-inch cyclotron, together with their full complement of associated experimental equipment, are among the best in their fields, and they are used in experiments which are now of primary interest to high energy physics.

The Bevatron, in particularly, is one of the two currently operating machines in the antinucleon field and has a large experimental program in full swing. One of the most important of the experimental facilities available to it is the recently completed 72-inch liquid hydrogen bubble chamber. This chamber, by far the largest now operable, presents an opportunity for research in its field unequalled elsewhere.

The immediate program, therefore, is based on increasing the effectiveness and utilization of these machines by increasing the experimental and support facilities and by accelerating the development of detection apparatus and data handling techniques. In the very near future the electron synchrotron will be closed down and the high-energy program will be concentrated on the two major machines. A low-energy program of modest proportions will continue to utilize the 60-inch cyclotron (and its successor, the 88-inch cyclotron) and the Hilac.

For the next period of approximately 2 to 5 years, three programs must take place concurrently. First is the continued utilization of the present accelerators at the highest rates of efficiency, and the continuing improvement of techniques and apparatus to produce the best experimental program practical within the Laboratory's capability. Second is the development of accelerator improvements for the short-range future. Third is the active study of new accelerator possibilities aimed at providing a future accelerator appropriate to the needs of high-energy physics in the years ahead.

From the data of preliminary studies it is possible to substantially improve the operation of the bevatron. By making certain modifications to the bevatron and to the surrounding experimental and supporting facilities it will be possible to obtain beams of significantly higher intensity. This will markedly extend its period of usefulness as a major instrument for high-energy nuclear physics research and will permit the performance of many of the complicated experiments presently impossible or impractical. The conservatism of the original bevatron design, together with its high degree of reliability in operation, not only makes such a plan possible but permits its very early accomplishment.

For the longer range period (5 to 10 years), the Laboratory will be engaged in an active experimental program with the modified bevatron, but at the same time it will be actively working on an accelerator development program which will open up higher energy and current ranges presently unavailable to high-

energy physics investigations. Such a program will take a period of 5 to 7 years of development and construction.

Because of the long timelag between planning and completion of a major accelerator project, we have been thinking along these lines for some time. While there is no definite plan as yet, and it is not clear whether greater energy, greater intensity, or both will be of more importance, or even what general type of accelerator will fit in best with the most advanced means of observation at the time of completion, some useful ideas have emerged.

The possibility of a more powerful accelerator must be kept open if we are to maintain our character as a research group working effectively in the forefront of high-energy physics. This machine should be located on or near the campus, in order to keep the present fruitful association with the existing facilities of LRL-Berkeley and with the university.

One idea which is now being examined is to put the new machine in the location of the present bevatron, using an air-core magnet cooled to low temperature in order to reduce its resistance. This permits the design of a compact magnet giving higher fields than can be reached with iron-core designs, and thereby allowing a higher energy for a given size of machine.

A tremendous advantage of this concept, if it proves to be practical, is that the elaborate experimental equipment which will exist around the bevatron will not have to be disturbed. The installation of the new magnet could be planned in such a way that the loss in bevatron time would not have a serious effect on the scientific program.

2. *Chemistry.*—The Laboratory has a unique standing in the field of nuclear chemistry. Its powerful family of particle accelerators furnishes both the materials for research on radioactive isotopes and the tools to conduct experiments on nuclear reactions and their mechanisms. The 60-inch cyclotron and the heavy ion linear accelerator are the principal machines being utilized. The 184-inch cyclotron and the bevatron are also being used but to a somewhat lesser extent.

The discovery of plutonium and other transuranium elements, the synthesis of a large number of radioactive isotopes (including important tracers), the development of widely employed methodology, and the training of many of the Nation's nuclear chemists have been among the products of this research group. In more recent years, comprehensive studies have been launched on problems of nuclear structure and reaction mechanisms. Although most of the members of this division received their training as chemists, they are being joined in increasing numbers by experimental and theoretical physicists. The chemistry and low energy physics research now underway covers a wide range.

The research on radioactive isotopes obviously depend on the available means of producing them. To increase the supply of transplutonium isotopes, an intensive production program was started 10 years ago with the assistance of other AEC laboratories and the Commission. This program has involved the irradiation of plutonium 239 in the highest flux reactors available, first at Hanford, then at Chalk River, and lately at the MTR at Arco. Of great promise for future research is the new national heavy element production program, involving efforts of this and other AEC laboratories. Additional amounts of plutonium are now being irradiated, with final irradiations to be made by the super high-flux isotope reactor, HFIR, being designed at Oak Ridge. This program promises to provide within the next decade greatly increased quantities of the heaviest isotopes, particularly californium 252, so important to studies of spontaneous fission.

The transmutation of elements to form new isotopes has always been an important part of the chemistry program. Major emphasis has been placed on the discovery of new elements, extending the periodic system. In the postwar years elements 97 to 102 inclusive have been added. The fission reaction has also received special research interest. The study of the chemistry of the transuranium elements has gone hand in hand with their preparation and the determination of nuclear properties. The knowledge of heavy element chemistry, the various aspects of the nuclear fission process, and heavy isotope radioactive decay properties is of obvious importance to the reactor program.

Research of the nuclear chemistry division is by no means confined only to the heaviest elements. Detailed studies of radioactive decay processes and of nuclear reactions induced by particles from the various Berkeley accelerators are carried out over the whole range of elements. The analysis of the radiation from radioactive substances by means of magnetic analyzers (alpha and beta-ray spectrometers) is one of the basic techniques employed. As one example, this

Laboratory has produced most of the curucial alpha-ray spectroscopic information for development of the most advanced theories of nuclear structure.

Other studies include atomic beam research, low temperature nuclear orientation, etc., which are of significance to the fundamental knowledge about nuclei, atomic structure and the solid state.

The future chemistry program will utilize the accelerators to an increasing extent. The 88-inch cyclotron will replace the 60-inch cyclotron as the major tool. The Hilac and the 88-inch cyclotron will have a unique partnership arrangement. For example, the discovery and pioneering studies of some isotopes of particular interest are now being made at the Hilac. The 88-inch cyclotron will then produce the isotopes in sufficient quantity to permit intensive studies. The 184-inch cyclotron and the bevatron, particularly after the beam intensity improvements, will find increased utilization for nuclear reaction studies.

The fundamental knowledge gained in research here has stimulated basic and applied research elsewhere, sometimes in unexpected ways. For example, the research findings on californium 254 led to far-reaching theoretical developments in astrophysics, such as the theories of supernovae and of nucleogenesis in general.

All of the chemistry programs depend on the continuous development of techniques and apparatus as a means of refining and extending the work. New techniques in chemistry, electronic instrumentation, radiation detection, the handling of radioactive materials (with special problems in the transuranium region), cryogenics, and in computer data processing and evaluation are under constant, vigorous development. Increasing applications of these techniques and apparatus are being made to problems far removed from those for which they were originally developed. These practical developments, as well as the basic research findings and training of scientists, constitute a major contribution by this Laboratory to the Nation's needs.

3. *Biology and medicine.*—From its inception, the biology and medicine group has utilized, modified, and contributed to the tools and techniques of nuclear physics and chemistry in its approach to research. The Laboratory's accelerators are very important to its work, both as producers of isotopes and as a source of ionizing radiation for many applications. Of the present accelerators the 60-inch cyclotron, the 184-inch cyclotron, and the heavy ion linear accelerator are of primary interest. One of the benefits from a close association with the other divisions of the Laboratory and the many related departments of the university is the utilization by this group of many scientific talents in their approach to research.

The future plans for this group can only be defined in general terms. They will continue the development and use of new experimental and theoretical tools of nuclear physics and chemistry in the investigation of the major unsolved problems in biology and medicine, including the radiation syndrome, cancer, blood disorders, and atherosclerosis. At the same time, this work will be carefully planned to avoid repetition of the work going on elsewhere. The following paragraphs indicate the more important studies that will be undertaken.

Cellular and subcellular radiobiology: Studies of the effects of radiation on cell division, of the "coding" problem—the method whereby the nucleus of living cells can store and transfer the genetic information, and of the radiobiological effects of very heavily ionizing particles similar to those of primary cosmic rays in space, using the Hilac, are some of the more important topics which will be investigated. The studies, while fundamental in nature, are of immediate interest in studies of defenses against the radiation syndrome and in a number of disease conditions.

Studies of the hemopoietic system: In the blood system the understanding of the control and proliferation of bone marrow cells in producing red and white blood corpuscles is of primary importance in protecting man from radiation injury. New techniques will be used in extending these investigations. The human urine factor "erythropoietin" will be comprehensively studied to explain its stimulation of new blood formation. The relationship of the pituitary gland hormones to the blood system and to the understanding of leukemia will be intensively studied.

Biomedical studies with cyclotron beams: The use of the 184-inch cyclotron for localized internal irradiation of selected tissues has been amply demonstrated by this group. The pituitary radiation therapy of breast cancer has shown great promise, and it is planned to expand this effort to other types of cancer, to hypertension, to leukemia, and to other of the severe and crippling

diseases. The aim of these studies is not only to alleviate the conditions but to understand the underlying causes.

The success of the cyclotron as a radiological tool, the need for further heavy particle studies for understanding space radiation conditions, and the increased physics program at the 184-inch cyclotron have resulted in studies of a potential medical cyclotron. Within a short period a definitive proposal may be made.

Other studies: Other studies which will be actively continued concern the experimental analysis of the theoretical developments on the effects of radiation and other factors on physiological aging; the fallout problem, strontium 90 metabolism and the long term effects of strontium 90 burden; and the lipoprotein studies—or interest because of changes caused in the lipoprotein system by irradiation injury and several types of cancer and leukemia.

The low background facilities soon to be completed will make possible the extension of the studies in gross body composition and of radiation levels in humans.

Another Laboratory group in the biology and medicine program is the bioorganic chemistry group. Extensive work is carried out in organic chemistry and animal biochemistry to determine radiation-induced fundamental changes, and in plant biochemistry to investigate the process of photosynthesis by nuclear methods. This group will intensively investigate solar energy work and radiation effects on pure organic compounds to increase the understanding of how radiation affects living systems.

As in nuclear physics and chemistry the ability to do biological and medical research also depends heavily on a continued development program of novel and sophisticated instrumentation and techniques.

4. *Inorganic materials.*—Within the Chemistry Division there has been a continuing program of modest proportions concerned with the basic physical chemistry of matter, with some emphasis on high-temperature thermodynamics. A few months ago the Laboratory made a proposal for the establishment of an inorganic materials research program. In addition to expanding and broadening the scope of the chemistry work done at the Laboratory, this program will increase the knowledge of the properties of materials, with special emphasis on the high-temperature regions.

This work is of primary importance to the national needs, for it has immediate application to advanced problems in reactor research and development, nuclear propulsion, controlled thermonuclear reactions, and space and missile technology. Again, the ability to enter such a program is the result of the university's attracting outstanding faculty members in the fields associated with materials research. Chemists, ceramists, metallurgists, solid state physicists, and mathematicians have been working together to make significant contributions to this field.

The immediate plan, i.e., through the next 5 years, is to establish the program and to start the work in the four areas of primary interest: High-temperature chemistry; physical chemistry of the solid state; metallurgy and ceramics; and general inorganic and physical chemistry.

The longer range program will be to expand the areas of primary interest and to intensify the work on particular subjects which become of major importance.

LONG RANGE PROGRAM LAWRENCE RADIATION LABORATORY—LIVERMORE SITE, 1959–69 [7]

Introduction

The Livermore site of the Lawrence Radiation Laboratory, University of California, has expended since its formation a large portion of its effort in the field of nuclear weapons development. In fact, the weapons program has been and is expected to remain the main purpose of the Laboratory even though other projects will probably be added to the overall Laboratory program. This should not, however, detract from the important work now being done by the Laboratory in other areas of research and development. At the present time, in addition to the weapons program, there are several other programs being

[7] Full text, as submitted by the Laboratory September 1959, except for deletion indicated by * * *.

pursued vigorously by the Laboratory. Following is a very brief listing of the Laboratory program:

1. Military programs:
   a. Nuclear weapons development.
   b. Nuclear ramjet development (Pluto).
2. Nonmilitary programs:
   a. Peaceful applications of nuclear explosives (Plowshare).
   b. High-temperature reactors research.
   c. Controlled fusion reaction research (Sherwood).
   d. High-speed computing.
   e. Geophysical research.
   f. Basic research.
   g. Educational program.

1. Military programs

a. Nuclear weapons development. (Discussed in a classified document.)

b. Nuclear ramjet development (Pluto).—For the past few years, the Lawrence Radiation Laboratory has been engaged in the feasibility study and the initial effort connected with the development of a nuclear ramjet engine. The role of the Laboratory at the present time is confined to the proof that a reactor of appropriate properties can be constructed and run on the ground. Presently, facilities are being constructed at the Nevada test site for the purpose of operating engineering test reactors. For the future, we believe that the Pluto program should proceed in stepwise fashion. The expenditure of a great amount of money on the ramjet can be postponed until feasibility and nature of the reactor is satisfactorily established. The reactor tests presently planned for Nevada should, however, proceed rapidly in order to avoid later pressure for an uneconomic crash program.

Following the initial phase of this program, the reactor has to be incorporated into a ramjet engine and it must be flight-tested. During this phase, skills will be required which are not available at the Lawrence Radiation Laboratory and could not be developed without a basic change in the nature and purpose of the Laboratory. We, therefore, believe that full responsibility for ramjet engine production certainly cannot be vested in the hands of the Laboratory. At the same time, we believe that it will be necessary during this phase of the development to make certain required modifications of the reactor and that these modifications can best be carried out by the same people who have developed the reactor. Thus, the Laboratory has this important responsibility to fulfill during this phase of the development.

The next phase in the development is that of production. This, we believe, should be the responsibility of an appropriate selected private company. In this respect, we expect that the same procedures would apply to Pluto as to other contracts between the Air Force and airplane companies.

c. General discussion of the problem of classification.—The overriding need for secrecy has set the weapons laboratories aside from other research institutions. In many instances, it has cut us off from valuable discussions with the scientific community. It has been a reason for reluctance of young scientists to join our ranks and it has, in some cases, slowed down the impact of our own results on a general scientific progress. These disadvantages are difficult to demonstrate from case to case. They are, nevertheless, real and their cumulative effect is great.

In the past years, declassification has eased these difficulties. The dissemination of knowledge on nuclear reactors has touched our Laboratory to a very small extent. On the other hand, the declassification of Sherwood has allowed us to obtain the advice of some excellent people. The long-range benefits of the exchange of information on Sherwood are likely to become most significant.

Short of declassification, there is the expedient of a proper extension of the group within which full discussion is possible.

The nature and functioning of the Laboratory during the next decade will depend to a very considerable extent on the policy of classification which will be adopted from now on. If it should be found that in an age in which we no longer possess a monopoly on nuclear weapons, classification can be further liberalized; this certainly will contribute to the health and effectiveness of the Laboratory.

2. Nonmilitary programs

In connection with the work performed throughout the past years in Livermore, there has developed a particular skill, a special set of equipment, and what is most important, a community of people with a unique know-how. We believe that all this capability can be best directed toward the field which is best described as applied science or advanced and inventive engineering.

These words cover a very wide field indeed. Within this wide field, we must select those special activities in which we have a best chance to make an outstanding contribution. In considering the long-range program of the Laboratory, we have, therefore, tried to avoid additional enterprises even though such enterprises may look interesting and challenging, unless we feel that we happen to be specifically equipped for a particular responsibility so that our duties can be performed in the most efficient manner.

a. Peaceful applications of nuclear explosives (Plowshare).—The use of nuclear explosives for peaceful purposes has been considered seriously in Livermore for almost 3 years. Nevertheless, the total amount of effort so far has been a very small fraction of the work of the Laboratory. Yet we believe that the potentialities of this development are exceedingly great. They can affect water transportation by the digging of harbors and canals. One can greatly increase the usefulness of water resources by the establishment of dams, by breaking up impermeable underground formations and by other means. Several attacks have been discussed on the problem of petroleum supplies, and while the difficulties seem great, the possible reward to the exploitation of tar sands and shales could have consequences beyond any present estimates. If one adds to the basic problems of water and oil, the further possibilities of big-scale underground chemical reactions, the creation of underground heat supplies and other proposals which may bear fruit, one can see a real possibility that the development of Plowshare may be of the greatest benefit to our country and, in fact, to people beyond our boundaries.

It is not to be expected that all of these possibilities can be realized and even less that they will come to fruition in the next decade. On the other hand, we are convinced that some very substantial successes will be achieved in the coming decade provided that the Plowshare program is vigorously pursued.

The role of LRL in this program should consist in the development of new tools and new approaches. The new tools include the invention of nuclear explosives which can be used for earthmoving purposes without dissemination of dangerous radioactivity. They further include the development of nuclear explosives of small yield at small cost. At the present time, we are hampered in our plans by the fact that, as a rule, nuclear explosives compete favorably with other methods of blasting only in case the explosion is big.

The investigations of new uses of nuclear explosives are concerned with containment of nuclear explosions, distribution of the radioactivity produced, changes in the rock adjacent to the explosion, and, generally, effects of the intense heat and pressure produced by the explosion.

Beyond the stages of the development of nuclear explosives and of the investigation of desirable effects that these explosives may produce there is a great abundance of challenging tasks in the field of the economical applications of Plowshare. The Laboratory does not propose to go deeply into these further developments. Indeed, we expect that these opportunities will greatly surpass in scope anything that the Laboratory could afford to do. We have discussed with Sandia Corp., with the Corps of Engineers, and with the Bureau of Mines such possible applications, and we hope that these as well as other Government organizations will participate in future developments.

Most particularly, we expect that private industry will take full advantage of the opportunities afforded by Plowshare. In addition to numerous expressions of interest, in one special case a substantial enterprise has been started by a private company (the Richfield Co. in connection with the Athabasca tar sands).

We hope that private companies will exploit the possibilities which are opened up as soon as this can be done with full effectiveness and with complete safety. We feel that we should limit our efforts to the developmental phase and to such assistance in further tasks which will be required by private industry.

Of course, there may occur applications of such magnitude which no private industry can undertake. If such a situation should arise, we feel that the Government should establish the proper methods of handling the situation and we believe that in such a case, the Laboratory will serve by making available

those tools and by performing those adaptations which will make the task easier.

b. High-temperature reactor research.—In connection with work on the nuclear ramjet, the Laboratory is acquiring special knowledge on high-temperature, gas-cooled reactors. The range of temperatures is very high; in fact, almost twice as high as any now planned for industrial uses.

Apart from a thermodynamic efficiency, high temperatures have the particular feature that the nuclear fuel and the fission products can diffuse more easily into the material of the moderator. This makes it possible to handle fuel elements in a more flexible and more economic manner. Chemical applications of these high temperatures could also be explored.

In case the reactor for the ramjet proceeds satisfactorily, the Laboratory has the long-range plan to turn its special knowledge gained in this high-temperature field toward peaceful purposes. In particular, the Laboratory should be interested in establishing a small-scale prototype of such a reactor. It will have to be seen later whether the Laboratory could do so on its own effort or whether cooperation with private enterprise would be preferable. In any case, we would like to limit our contribution to the establishment of the feasibility of an economical high temperature, gas-cooled nuclear reactor. We hope that in case we succeed, other agencies, and most particularly private industry, will be in a position to exploit the advances which we may have made.

The Laboratory recognizes that in the general field of nuclear reactors our country possesses great and effective research institutions, such as the Argonne National Laboratory, the Oak Ridge National Laboratory, and the Brookhaven National Laboratory, with which, as a general rule, we do not desire to compete. Consequently, we want to limit our contribution to the special field of ultrahigh temperature, gas-cooled reactors in which field we are gaining experience due to work in line with present responsibilities.

c. Controlled fusion reaction research (Sherwood).—The Lawrence Radiation Laboratory, in Livermore and in Berkeley, has been among the first who in this country have attacked the problem of controlled fusion. The status of this problem is now, according to general agreement, as follows:

(1) Feasibility: To establish a controlled thermonuclear reaction one has to confine an extremely high-temperature ionized gas (plasma) with the help of a magnetic field. The problem of the production and confinement of a sufficiently hot plasma appears to be most difficult. In a broad international effort in which our Laboratory has played a vigorous and reputable part, many reasons for these losses have been discussed and understood. There is expectation that within the next 10 years a working model of a controlled thermonuclear reaction can be established. At the same time, it must be pointed out that this is only a hope and not a certainty. In case there should be success, we feel sure that our Laboratory will contribute in an important way to such a success.

However, it must be fully realized that even a successful model of a controlled thermonuclear reaction will not make economical exploitation of controlled thermonuclear power immediately available. Considering the difficulties encountered so far, the Laboratory expects that it will be several decades before Sherwood will produce a plant that can successfully compete in energy production with conventional or nuclear power sources.

(2) Advantages: In case an economical powerplant based on Sherwood plans can be established, the following advantages are expected:

(*a*) Inexpensive and practically inexhaustible fuel.

(*b*) Better control of byproducts. The thermonuclear reaction produces fewer and more easily controlled radioactivities. Generally, the hazards connected with such a reactor are expected to be much smaller than those connected with a fission reactor.

(*c*) Direct conversion of a substantial part of the thermonuclear power into electricity. The methods now contemplated in confining the hot, ionized gas lend themselves in a simple and natural fashion to the problem of direct conversion. This, in turn, may substantially decrease the expense of auxiliary equipment.

(3) Short-range benefits: The investigation of controlled fusion has led us into a thorough scientific study of the behavior of hot ionized gases of plasmas. These plasmas play an important role in electrical discharges. It is to be expected that before Sherwood will solve the difficult problem of controlled energy release from fusion, it will have led to new and usable techniques in the handling of electrical discharges and connected phenomena.

(4) Recommendations and relations to industry: In the past 2 years, most effective research teams have been built up dedicated to the solution of the prob-

lem of controlled thermonuclear power. In the absence of an expectation of early success we do not intend further to increase our team. On the other hand, we believe that it would be wasteful and inefficient not to encourage this expert group to pursue further the scientific and technical investigations which we have described above. In the last year, the work of this group has been greatly invigorated by the declassification of Sherwood and by wider cooperation with the scientific community and with industry. We believe that the industries and the scientific institutions should be encouraged to take an increasing part in the Sherwood research, particularly, if they do it in fields in which that industrial or scientific institution already possesses some special knowledge. On the other hand, we do not believe that the concentrated high-grade effort represented in the several Sherwood laboratories in this country could be quickly or effectively replaced by industrial teams. The Laboratory, therefore, recommends that the Sherwood effort in the Lawrence Radiation Laboratory should continue at the present level and along established lines.

(*d*) High-speed computing: The solution of complicated and difficult physical problems through the aid of high-speed computing machines has already become a very important activity within the Laboratory program. It is certain to be even more important in the Laboratory's future activities. Certain problems relative to weapons' design have been the most complex hitherto solved. There are, however, very large numbers of such problems in newly developing scientific fields, both applied and fundamental. The Laboratory has an unsurpassed combination of experience in the use of computing machines together with the ability to analyze physical situations mathematically in a form appropriate to numerical solution of differential equations. We foresee in the next decade that this method will be applied to other problems, ranging from meteorologic to the field theory of elementary particles, and we expect to be in the forefront of this activity. For this purpose it will be necessary to acquire and perhaps also to participate in the design of computing machines of increased memory capacity and increased speed, as components which allow such advances become available. Almost 10 percent of the Laboratory's operating budget has been spent on computing facilities and operation (including a large staff of programers) and we fully expect this situation to continue.

(*e*) Geophysics: In considering the long-range program of the Laboratory, we have come to the conclusion that the field of geophysics is one in which we might, under proper circumstances, make a worthwhile contribution during the next decade. Among geophysical topics, we first want to consider meteorology.

In order to perform other duties, the Laboratory must have an excellent set of high-speed computing machines. What is even more important, we must have the ability to solve the problems in physics, mathematics, and computation which are necessary to predict the outcome of involved processes in which hydrodynamics plays an important part. We believe that in this particular field the Laboratory has unique capability.

A small portion of this talent and this equipment could be turned toward the important problem of weather prediction. At present, an exceedingly small effort is devoted to this particular purpose. Our immediate plan in which only two or three people are involved is not to make progress in the field but to evaluate our capability of making real progress if greater effort were to be employed.

It is obvious that weather prediction in itself is of extremely great importance, both on the national and the international scene. One should further remember that any further possibility of weather modification is closely connected with the question of weather prediction. In fact, without weather prediction, no procedure of weather modification can be reliably judged and evaluated.

Our computing machines and our expert physical and mathematical analysis capability are not our only asset in the field of meteorology. Radioactive materials from nuclear tests have helped to elucidate some important problems of general circulation. In particular, they have made a basic contribution to the understanding of the stratosphere. We believe that use of radioactive materials may be exploited more sensitively and, therefore, more fully. Our radiochemists and more generally our group concerned with bomb diagnostics could make important contributions in this field.

There are other branches of geophysics in which the Laboratory has at present an interest. In connection with the observation, detection, and hiding of nuclear explosions we have acquired some expertness in high atmosphere physics,

in electrical phenomena of the atmosphere and in seismology. Future nuclear explosions could give valuable further information, both about seismology and the nature of the upper atmosphere. Part of this work would have to be undertaken as a joint effort with the national satellite program. It would seem to us proper to approach these problems in a thorough scientific spirit and to pursue them as far as possible in full cooperation with the whole scientific community.

f. Basic research.—It is necessary for the continued health of a scientific laboratory to devote some of its efforts to pure research. This is of importance for many of the individuals who are at their best if they can participate to some extent in basic scientific work. It is also of importance for the standing of the Laboratory. Without significant publications, the Laboratory's reputation cannot be kept at a sufficiently high level and the Laboratory's ability of recruiting and keeping outstanding people will suffer. Finally, the cross fertilization between pure and applied scientific efforts cannot be overestimated.

Among the many possibilities of pure scientific work, the Lawrence Radiation Laboratory at Livermore has concentrated upon those few which are either particularly relevant to our other efforts or for which we are particularly well equipped.

We have paid and we are planning to pay considerable attention to low energy nuclear physics or neutronics. This is a field of great importance in connection with the development of nuclear explosives and of reactors.

A small percentage of our excellent computational equipment has been devoted and is planned in the future to be devoted to purely scientific work. Thus, we have performed calculations about the interior constitution and development of stars and we have also used our equipment to analyze the behavior of elementary particles which topic at present commands top interest among the physicists of the world. These are just two examples and future work might vary to a great extent, being adapted in each case to the particular opportunity to use our machines to the best scientific advantage.

A whole new class of possibilities in pure research is likely to open up in connection with work on Plowshare. Nuclear explosions can be a source of many phenomena whose scientific investigation is of great value. Thus, nuclear explosives may become the best source of sharp neutron pulses and nuclear explosives could be the best means of producing new elements, thereby extending our knowledge of chemistry. Nuclear explosives might also be used to study the earth's interior and the wide region extending from our atmosphere into interplanetary space. These two last topics are on the borderline between pure and applied science and have been already mentioned in the previous section.

g. Education.—One area in which the Lawrence Radiation Laboratory in Livermore can make an increasingly large contribution is in the field of education. The distance between Livermore and the Berkeley campus prevents a really effective association. A close and effective association could serve as a source of fresh minds to the Laboratory, as an opportunity for young men in the Laboratory for further education, and as a chance for some of our more advanced people who want to accept joint appointments to keep up an invigorating interaction with the inquiring minds of students.

At the same time, the unclassified skills developed in our Laboratory are a treasure which should be passed on to the next generation in the most effective manner.

Of course, it should be clearly understood that in any such collaboration a distinct line must be drawn which would permit separation of the classified part of the work at the Laboratory from the necessarily unclassified instruction and research at the educational institution.

It would be premature to suggest in this report in what partciular way an effective educational link can be established. Association with a technical institute might be one way. The establishment of such an institution in the Livermore Valley has been suggested to the regent of the University of California. It should be pointed out, however, that a reasonable solution of this problem will have decisive influence on the health and vigor of the Laboratory during the next decade and in the further future.

Anticipated growth of the Laboratory and level of support required

The use of the Livermore Laboratory was started in 1952 with a nucleus of approximately 250 people to further weapons research and development. From this modest beginning, it has grown to 3,700 in 7 years and added programs in

controlled thermonuclear reactions, nuclear propulsion, and peaceful uses of nuclear explosions. In addition, a substantial computational group has developed. Here, once again, the size has been dictated by requirements of the various programs.

This rapid increase has not been without problems and we would not like to have the next 10 years continue at such a rate. An increase of 5 percent per year, however, could be readily absorbed but even this should respond to program demands. This could bring our staff to 5,600.

Work at Livermore suffered greatly at first due to lack of adequate plant and equipment. Programs demands and people far exceeded available space to take care of requirements. When the present construction program is finished in about 1 year, good facilities will, for the most part, be available to support only 3,700 people. The exceptions are those activties housed in the old wooden buildings. These should be replaced with modern, efficient structures. Beyond such a point, new facilities should be geared to program increases, specialized units, and obsolescence.

LOS ALAMOS SCIENTIFIC LABORATORY

Comments concerning the ensuing 10 years [3]

The Los Alamos Scientific Laboratory was established under a contract with the University of California in the early part of 1943 to provide a focal point for the previously diversified research directed toward the feasibility of an atomic bomb. Its initial staffing was partly military and partly civilian, although the major technical direction was primarily the latter. It attained its wartime peak strength during the summer of 1945, with about 1,500 civilians and 2,000 military personnel more or less directly involved in Laboratory activities.

The Laboratory conducted the first nuclear test at Alamogordo on July 16, 1945, and provided the actual bombs and the technical crews associated therewith for the strikes against Japan immediately thereafter.

By the time of the adoption of the Atomic Energy Act of 1946, the technical military staff of the Laboratory had essentially vanished and the civilian staff had decreased to about 1,300. Nevertheless, the Laboratory successfully provided the nuclear devices for use in Operation Crossroads at Bikini in 1946 and participated in other technical aspects of this operation. Following the adoption of the Atomic Energy Act of 1946 and the decision by the AEC to continue the Laboratory as a permanent institution under the continuing administration of the University of California, the Laboratory began to increase in size, ultimately reaching approximately its present strength of 3,250 by about 1956. Its size has been primarily limited by the availability of local government housing and has remained essentially constant over the last several years.

During the first half dozen years after the war, the Laboratory concentrated almost all of its programatic attention on problems of atomic weapons development climaxed by the successful development of the thermonuclear fusion process in 1951. Since then, the Laboratory has broadened the base of its activities by applying various of the skills and technologies developed in connection with weapon activities to other areas of national interest.

The current missions of the Los Alamos Scientific Laboratory follow:

"General conduct of basic and applied research in the fields of nuclear weapons, thermonuclear and fission power programs, and nuclear rocket propulsion systems. The Laboratory contains research facilities and equipment appropriate to fundamental research in nuclear physics, chemistry, metallurgy, and cryogenics; computational techniques, biophysics, and biochemistry. Research is conducted in all of these fields."

The primary mission of the Laboratory is weapons development. In addition, a major mission of the Laboratory is the study of the feasibility of nuclear rocket propulsion. In this field the Laboratory is responsible for—

A. Theoretical design and system studies of various types of potential uses of nuclear energy for rocket propulsion;

B. Experimental studies of the behavior of materials under the conditions of temperature, radiation, and propellants appropriate to various designs of nuclear rockets;

[3] Full text, as submitted by the Laboratory, Sept. 14, 1959, and Nov. 12, 1959, except for deletions indicated by * * *.

C. The construction and operational test of prototype and preliminary models of various types of nuclear rocket engine systems in order to evaluate their problems and potential feasibility for actual propulsion use;

D. Participation with NASA and other agencies in system studies potentially utilizing nuclear rocket propulsion;

E. Participating in the nuclear aspects of full-scale nuclear motor or nuclear flight tests in collaboration with NASA.

Another major mission of the Laboratory is the study of the production of power from the fission process. In this field, the Laboratory primarily concerns itself with—

A. Nuclear reactor systems in which the cost of fuel refabrication is minimized through the use of homogeneous or mobile fuels;

B. Systems which burn plutonium particularly under conditions when a breeding cycle is effective;

C. Very high temperature gas-cooled systems whose character, in part, may be related to technologies developed in the nuclear rocket systems;

D. Systems in which there is a direct conversion of thermal to electrical energy, such as the plasma thermocouple.

Another mission of the Laboratory is the study of the possible production of power from the thermonuclear fusion process. In this field, the Laboratory primarily concerns itself with—

A. The theory and experimental characteristics of the "pinch" effect;

B. The construction, study, and understanding of various Laboratory size devices exploring the containment, stability, temperature, and neutron production of differently generated and contained plasmas.

A further mission is biomedical research, including such programmatic investigations as—

A. Studies (by whole-body counting methods) of the absorption and retention of radioisotopes, and extrapolation of this experimental data to humans to provide more accurate establishment of maximum permissible levels;

B. Studies of the physiology and toxicology of plutonium to provide a firmer basis for the maximum permissible body burden of this important nuclear material;

C. Radiobiological and biophysical instrumentation problems associated with development and use of nuclear systems in manned and unmanned space missions;

D. Problems of biospheric radioactive contamination, from both nuclear detonations and primary or auxiliary nuclear power supplies;

E. Development and use of scintillation counting techniques (especially low background, whole-body detectors) for diagnostic and clinical medicine and for the assay of biospheric contamination;

F. Development of more satisfactory radiation dose measuring devices (including depth dosimetry) in mixed radiation fields, as occur in criticality accidents.

A final mission of the Laboratory is participation in the scientific life of the United States through basic research and its publication in those areas which are peripheral to and stimulate the more specifically programmatic missions of the Laboratory, through cooperation with education and industrial research institutions, and through participation in programs designed to improve the national level of scientific education and achievement.

Weapon research and development of LASL

[Discussed in a classified document.] * * *

Activities of the LASL and their relationship to universities and industry

What is the relationship between LASL activities and those of universities and industry and could any be transferred?

There exists a great similarity between many LASL research activities in nonweapon fields and similar activities carried on in universities—usually with Government funding. In any laboratory with programmatic responsibilities and objectives, a broad basis of research is imperative to provide the best atmosphere for productive scientific activity. Laboratories without such research activities soon cease to have now ideas and become dead. Laboratories like LASL do, indeed, do research like universities—and it has been one of the important sources of their strength. Take it away or decrease it and the health of the Laboratory will suffer extraordinarily rapidly.

It should also be pointed out that most proposals to transfer activities to universities or industry always involve Government support along with them. It is cheaper and more effective for the Government to do its work in its own laboratories than it is to farm it out. Small research contracts are frequently ineffective—the concept of adequate staffing and adequate varieties of intellectual disciplines should be maintained so that Government laboratories always have very much more than a "critical mass" of people.

It should also be pointed out that the existence of strong, ingenious and versatile research groups is an important asset to the Government in taking on new and, particularly, classified programmatic objectives in a hurry. As an example, the existence of a strong group of nuclear physicists with appropriate supporting group has been effective at Los Alamos in the past support of testing programs as well as in certain high priority proposals now being made.

In general, while it is always possible to transfer almost any kind of work away from Los Alamos (except, probably weapon work), it will cost the Government more, it will be less well coordinated, and it will seriously and adversely affect the Government's chances of getting important work (including weapons work) done rapidly and effectively in its own laboratories.

It may finally be pointed out that the only large-scale programs which have been really well done have been done by the Government in Government laboratories operated by industrial or academic contractors. Radar, the proximity fuse, and the atomic energy program are conspicuous examples. Universities, by themselves, have done nice but uncoordinated research programs. * * *

General comments on the future of LASL

It is probable that the overall size of the LASL should show only slow growth over the next decade—a growth permitted primarily by the availability of additional housing as areas such as Barrancas Mesa and White Rock are opened up. * * *

Perhaps the greatest single question is whether, under a maximum of weapon responsibilities, this will permit adequate progress to be made in areas such as nuclear rocket propulsion, plutonium-burning reactors, and similar fields in which the LASL has a unique capability and one which could be duplicated or installed elsewhere only at extraordinarily great expense. This question cannot be answered in a quantitative sense at the present time.

FUTURE ACTIVITIES OF THE SANDIA CORP.[*]

Summary of nonweapons aspects of statement

Sandia Corp. has been and is today occupied mainly in the field of weapon development. It is important to note, however, that the unique capabilities of Sandia, in terms of both the size and caliber of its staff and the facilities it has available, permit it to undertake other tasks.

In the topics listed below, we have therefore included areas of increased or new effort for Sandia.

1. *Increased effort in basic research and exploratory development.*—Basic research in fields related to the needs of our business is underway and is being increased as scientists of the proper qualifications and interests can be acquired. Applied research and exploratory development programs seek to apply new knowledge or to find new applications of old knowledge. Mathematical research seeks new methods or techniques in statistics, numerical analysis, or system studies.

2. *Environmental effects.*—It has been recognized that environment may affect the operation of nuclear weapons. Facilities are being installed at Sandia which will make possible a thoroughgoing program in this field covering both the scientific and engineering aspects of the problem. Modest effort is already underway.

3. *Detection systems.*—Some work is in progress at Sandia relating to aspects of the detection of nuclear explosions.

4. *Project Plowshare.*—Sandia can, we believe, contribute to Plowshare in at least three ways. First, we are conducting cratering studies with chemical explosives with the purpose of finding how best to arrange nuclear explosives for various kinds of excavations with maximum containment of radioactive products. Second, we are helping LRL plan various projects and assisting in

[*] Dated Sept. 12, 1959.

the necessary instrumentation with particular reference to fallout, shock damage, and other safety problems. Third, at some future date it will probably be desirable to develop nuclear explosives designed specifically to meet the needs of the Plowshare application rather than military requirements. Consideration of economy and how to minimize fission products will probably be paramount, while size and weight will be less important. It seems only natural to expect that Sandia will be heavily involved in such development.

5. *Specialized reactor design.*—Recently Sandia has carried out for LASL considerable planning and design work on the Turret reactor with the expectation of building an experimbental model of the reactor in Albuquerque. Although this plan was not approved, this effort suggests a role that Sandia can play in the AEC's reactor program. The design capabilities of Sandia coupled with its experience in the field of materials fitted well the Turret problem. The experience gained on this project, as well as other work on Rover, has given us confidence that we are well equipped to handle similar problems in the reactor field. For example, the development of portable reactors for the military could very well be assumed by Sandia.

Future size of Sandia: Facility requirements

Sandia is today operating with a manpower ceiling of 8,000. It is our recommendation that this ceiling be held.

As a laboratory Sandia is today well equipped with facilities and several new ones are under construction or approved. In terms of buildings, the situation is not so favorable, and a large part of the staff is housed in inadequate, costly-to-maintain, wooden structures, some of them buildings built for use by CCC camps in the late 1930's. Most urgent is a continued construction program aimed at replacing these worn-out buildings. We foresee, therefore, continued funding requirements of a few million dollars annually to cover some new facilities, replacement of old facilities and the construction of new buildings.

Sandia's activities in relation to private industry

Early in Sandia's history atomic weapons were assembled at Sandia and some of the components and auxiliary equipment produced there. As the AEC manufacturing complex was built up, and as we developed reliable subcontractors, the production activity of Sandia was reduced.

Sandia has evolved through the years, therefore, into an organization primarily engaged in research and development activity and in certain "engineering for manufacture" functions, but not in manufacturing per se.

On the matter of weapon development, with its special problems of security and safety, there seems to be no question that such activity should be a responsibility of the AEC and hardly one that can be contracted to private industry. In some of the areas of new activity for Sandia proposed early in this memorandum, one might raise this question. Here, too, we believe the role suggested for Sandia is proper. In Project Plowshare, for example, we anticipate that eventually private industry will participate in the planning and preparation activity. However, the AEC will have to retain responsibility for detonation of nuclear explosives and safety matters surrounding the problem. We foresee Sandia serving as the technical arm of the AEC in such matters. Detection systems again should be a closely held activity of the Government, and so we believe Sandia's role in this program is proper. In the reactor development field, we believe that there is a proper role for Sandia, even though this is certainly a large area suitable for private enterprise also. Those reactors which involve advanced concepts are, however, high-risk ventures for private industry, unless the work is fully subsidized. In this area of research and development on advanced reactor concepts and in the construction and test of small-scale experimental reactors, we believe that Sandia can make significant contributions and still not preempt a field rightfully in the domain of private industry.

Such a diversified program will result in retention and even strengthening of its present staff.

SUMMARY OF LONG RANGE PROGRAM SUBMITTED BY HANFORD ATOMIC PRODUCTS OPERATION [10]

[This summary discusses the research and development capabilities of the entire Hanford complex, rather than the Hanford Laboratory alone. Of the 580

[10] Dated Oct. 29, 1959. The text of the summary is reproduced as submitted, except for deletions required because of classification.

professionally trained personnel referred to, about 500 are employed at the Hanford Laboratory. The remainder are engaged in such activities as analytical work, serving all Hanford operations.]

Background and history

The research and development organization at Hanford was established to provide technical support for plant activities associated with the production of plutonium and of [certain] weapons components. Primary emphasis was placed on applied research and development in technical areas associated with fuels, reactors, chemical separations, plutonium fabrication, and radiological safety. These efforts contributed importantly to major increases in production rates, drastic reductions in production unit costs, and maintenance of radiation safety in the plants and their environs.

Following completion of a major expansion of plutonium production facilities, it was found possible to divert a portion of the personnel and facilities to the support of other Commission programs. Thus, Hanford's research and development efforts have been broadened over a 3-year period to include significant peaceful aspects of atomic energy. Important examples of such programs include (*a*) developing plutonium as a power reactor fuel material (the plutonium recycle program), (*b*) basic studies covering major aspects of radiological safety, (*c*) power reactor fuel reprocessing, and (*d*) fission product recovery. These programs and those associated with production efforts have proved, as anticipated, to be mutually supporting. A significant share of the technology developed in one type of program is frequently of demonstrable benefit to the other.

Professional manpower resources

The Hanford staff has acquired considerable breadth and depth of competence in fields such as reactor physics, reactor engineering, graphite technology, plutonium and uranium metallurgy, chemical separations technology, radioactive waste disposal, and radiological and nuclear safety.

Approximately 580 professionally trained personnel are now engaged in research and development at Hanford. Considering the relative youth of atomic industry, the Hanford research and development team must be considered as being seasoned and mature. About 20 percent of the professional personnel hold Ph. D. degrees, and another 20 percent have M.S. degrees. More than half of those holding advanced degrees have more than 10 years of experience in the nuclear field.

The force has an unusually diverse representation of scientific and engineering disciplines. In all, there is a balance of about 60 percent science with 40 percent engineering.

An important characteristic of the manpower resource is that the production-oriented research has historically required a high quality of science and a high quality of scientist. Such men, difficult to retain in closely directed research, have been stimulated to top performance by the recent broadening of program opportunities.

Facilities

Throughout the years much use has been made of actual production facilities in carrying out experimental programs. Facilities specifically for research and development represent an investment of about $48,500,000 now in place. For the most part, the laboratories are modern and well equipped. Equipment is available to perform investigations ranging from basic measurement of neutron interaction with materials to prototype testing of large size reactor components.

Among the many unique facilities are high-capacity in-reactor test loops, a versatile physical constants testing reactor, and a full-scale simulation heat transfer apparatus.

Other important facilities costing in excess of $25 million are now under construction and will soon be placed in service. Chief among these are the plutonium recycle test reactor and a plutonium fabrication pilot plant. These will be used as tools in the development of plutonium as a power reactor fuel material. Construction is also underway on a plutonium critical mass laboratory to support studies related to nuclear safety in chemical separations plants.

Current distribution of effort

The total research and development expense at Hanford now approximates $22,800,000 per year. The bulk of this work relates to assuring continuity of production, improving nuclear and radiological safety, and achieving increased productivity of plant assets through increased production and/or reduced costs.

This includes intensive current activity in technical support of the design and construction of the $145 million new production reactor (NPR) and its related fuels and chemical separations requirements.

The balance of the research and development at Hanford is devoted to programs sponsored by the AEC Divisions of Reactor Development, Research, and Biology and Medicine. Such programs now involve $8,800,000 per year and involve the participation of 240 professional personnel. The major effort comprises the plutonium recycle program $5,100,000 per year) and the radiological sciences programs ($2,200,000 per year).

Other programs oriented independently of production objectives were also started, mostly in 1958. They include work on reactor physics and graphite behavior in gas-cooled reactors in support of programs at the Oak Ridge National Laboratory. Some work is done in the fields of power reactor radioactive waste disposal, effects of irradiation on metallic fuels for power reactors, and nondestructive testing of fuel elements.

The selection of programs in fields beyond the basic needs of plutonium production has been based on the existence at Hanford of particular competences, specialized facilities, or both, applicable to some field where new knowledge is needed.

In a program as large as the plutonium recycle program there will obviously not be a complete 1-to-1 correspondence between needed and available competences and facilities. Thus some strengthening of both is natural and proper. A continuing virile resource will thus be available as new needs for technological information develop in the future.

Plans related to plutonium production

Hanford's production programs are delineated yearly and projected for 5 years in advance. These form the basis for planning research and development programs necessary to achieve targets.

In addition to providing technical support for the new production reactor (NPR) program, technical programs are planned for the next 5 years to achieve ambitious and profitable returns in terms of substantially improved production from existing plants.

Also to be undertaken are programs bearing on the recovery of fission products and of special isotopes for military uses.

The total of these efforts comprises a continuing program, of about 5 years' duration, requiring the services of about 340 professional personnel. Following completion of NPR construction, design personnel needs will decrease but research and development personnel requirements are not expected to change much. Most of the technical personnel available from the NPR program will be required to support potential increases in plant production output in fiscal years 1962 through 1964, and to provide means to increase the efficiency of the NPR after it is complete.

For the 5-year period following fiscal year 1964, it is not now possible to forecast technical personnel needs with precision. So long as production continues at maximum capability, a substantial staff will be required. At some point, investment in research and development to increase production further in an existing plant should reach a point of diminishing returns. At such time a significant number of trained professionals and special facilities would become available for use in other Commission programs.

The above planning is predicated on the assumption that military demands for plutonium require Hanford to maintain output at high capacity. Under other assumptions, an earlier diversion to other technical activities may be appropriate.

Plans for programs not related to production

The plutonium recycle program is the major Hanford research and development effort outside the scope of plutonium production work. The program aims at developing technology related to the use of plutonium in power reactor fuels. This represents an area in which the national store of knowledge is yet quite meager. Its execution for the Division of Reactor Development at Hanford reflects Commission recognition of special competence and facilities at Hanford related to plutonium technology. The focus of the program is broad and relates to all aspects (physics, chemistry, reactor, and fuels) related to the recycling in thermal reactors of plutonium recovered from discharged fuel elements. Continuance of the program for a period of 5 years or more, at a level of from $5,100,000 to $6,700,000 per year, is contemplated.

The next largest program in force encompasses all major fields of the radiological sciences. The need for improved understanding in these fields is widely recognized. These programs are executed for the Division of Biology and Medicine and were originally undertaken in direct support of plant operations. The present program amounts to $2,200,000 per year. It is recommended that these programs continue at levels consistent with the national needs as nuclear activities become more widespread.

Hanford's preeminence in the field of nuclear graphite technology and in the physics of graphite moderated reactor systems led to Hanford contributions to the gas-cooled reactor studies program. This program, where basic data is vitally needed, should continue.

Another area in which Hanford's background and experience are directly applicable to national nuclear problems, involves the disposal of highly radioactive wastes from chemical processing plants handling power reactor fuels.

Hanford has considerable experience in the safe handling and storage of production reactor fuel wastes and is engaged in research and development to devise safer and more permanent storage of these. Extension to the special problems of power reactor fuel wastes represents efficient use of available skills and experience.

Solution of problems encountered in using metallic fuel elements in Hanford reactors has resulted in the development of unusual competence in the field of metallurgy. Likewise, problems encountered in recovering plutonium and other elements in separations plants have led to the establishment of unquestioned abilities in the field of transuranic element chemistry. Modest programs in these areas are now in progress. These relate to the fundamental chemistry of the actinide elements and the basic mechanisms involved in the swelling of metallic fuel elements on prolonged, high temperature irradiation. Continuance of such programs is appropriate.

In addition, from time to time other quite specialized basic problems will be seen to be uniquely suited to Hanford attack. In total, this basic research will properly be relatively small. The returns, both in terms of provision of new data and of stimulation of all Hanford research forces, will be disproportionately high.

Further projections

It is expected that additional areas in which Hanford strengths are exceptionally well suited to solving nuclear technology problems will develop. In a rapidly developing field it is inappropriate to crystallize these areas now. Some that are currently seen are briefly mentioned below.

Hanford reactor technology is strong in the field of graphite moderated, pressure tube reactors. More advanced systems may be suitable for pressurized water, boiling water, or organic cooled operation. Hanford participation in conceptual studies to appraise these potentials is appropriate.

Similarly, basic studies in the broad field of thermal reactor physics is needed nationally and fits local capabilities. In both these cases there may be a tendency to compartment the efforts prematurely for application to a specific reactor type.

Broad competence in radiological sciences should be applied more and more to universal problems. Typical would be reactor hazard work, including release of fission products from fuel, meteorological factors, and improved confinement.

On a national basis, study of plutonium as a reactor fuel is in its infancy. Both directly through the plutonium recycle program and in logical extensions to other plutonium systems, outstanding Hanford skills can be applied.

There is already a diversity of experience in special irradiations. Some specific applications of new materials are being studies. Undoubtedly, some will deserve exploitation.

Hanford experience with metallic fuel elements is extensive indeed. Use of metallic fuel elements in most power reactor concepts is today limited by considerations as to irradiation induced swelling, and corrosion problems in water-cooled reactors. Should these technical problems be solved, increased interest in metallic fuels will result. Hanford's metallurgical know-how and extensive semiworks facilities would be well suited to the development of low-cost fabrication methods for fuel elements of this type.

Programs for other Government agencies

Hanford's potential participation in research and development programs for Government agencies other than the Atomic Energy Commission could most logically be expected to involve those associated with nuclear energy in one form or another. In this regard, very modest assistance is now being rendered to the U.S. Maritime Commission (construction and operation of a gas-cooled in-reactor loop) and the U.S. Air Force (special meteorological experiments and biological work). Other agencies whose interests could be served, at least in an occasional supporting capacity, are the National Aeronautics and Space Agency (nuclear rocket propulsion, high temperature materials development, and satellite power sources), the U.S. Army Quartermaster Corps, and the Department of Agriculture (bulk irradiation of foodstuffs and deinfestation of seeds, etc.), and the U.S. Department of the Interior (saline water conversion and commercial nuclear explosives). A systematic study of these possibilities has not been made and these observations are suggestive only.

Recapitulation

To summarize, Hanford's considerable skills, competence, and facilities assembled to support production programs represent a national asset which can and should be increasingly applied to the solution of technical problems related to the peaceful aspects of atomic energy.

A high rate of return is anticipated in those cases particularly where there is cross-fertilization between production-oriented programs and new work. The total level of technical effort, measured in terms of professional manpower is not contemplated to change very rapidly either upward or downward. On the whole, a slow and progressive shift to a higher percentage of nonproduction oriented work seems likely. Optimum use of the Hanford resources could possibly come from quite modest increase also in total effort.

SAVANNAH RIVER LABORATORY 5-YEAR FORECAST [11]

The Commission has requested that a 5-year forecast of work at the Savannah River Laboratory be prepared for planning purposes. We should first like to point out that development forecasts are extrapolations from current knowledge but that the actual development programs are in large part dictated by a number of factors that cannot be predicted, such as the rate at which development successes are achieved, requests for work on new processes, technological breakthroughs, and the occurrence of unforeseeable process problems. For these reasons the validity of a 5-year forecast varies from reasonably firm for the first year to quite tenuous for the fifth.

The Savannah River Laboratory was established as an integral and necessary adjunct to the Savannah River plant for the purpose of supporting the plant's production objectives. It is our understanding that the purpose of this forecast is to obtain some idea of what might happen to the development work required for production support in future years, and thus to obtain a measure of the manpower and facilities that might become available for other work. To assist in this survey, this document provides (*a*) information on production support programs that are likely to be required 5 or more years hence, (*b*) comments on the possible future course of power reactor studies, (*c*) a guess on average future manpower requirements for power reactor studies, (*d*) a brief description of manpower and facility resources of the Savannah River Laboratory, and (*e*) a list of nonproduction fields in which the Laboratory could make contributions in the national interest.

SAVANNAH RIVER LABORATORY PROGRAMS

For reasons of administrative convenience and control, the work of the Savannah Laboratory is conducted under three spheres of activity or programs. The reactor process development program covers all reactor physics and reactor engineering studies. [A substantial part of the future work will be aimed at achieving maximum productivity and lowest unit cost consistent with safe operation.

[11] Full text as submitted by E. I. du Pont de Nemours & Co., except for certain deletions required by classification and except for a classified appendix dealing with production support. Dated May 7, 1959.

Studies related to reactor safety will be conducted on a continuing basis as well as studies needed to keep chemical problems of the reactors under control.] [12] The metallurgical development program covers all fabrication work on fuel materials and work on materials of construction. [Work in these areas is expected to continue.] [12] The chemical processing development program covers all work on chemical and chemical engineering processes such as separations and heavy water production. [While development efforts required to support current separations processes should decrease as time passes, development work will be required to adapt these processes to possible new fuel parameters. It is important that basic work on separations chemistry and equipment should be continued not only because of the improvements that can be made in current and similar future processes but also because such advanced technology will facilitate the development and initial economy of future new processes that may be needed.] [12] The following information covers only work that probably will extend to 5 or more years.

Power reactor study

The recently prepared fiscal year 1960–61 budget covers only about 6 months' initial operation of the HWCTR. It should be noted that at full power a burnup of 6,000 MWD/ton would require a cycle of about 9 months. We believe that a continuation of this study for several years after fiscal year 1961 will be necessary for purposes such as the development of economical fuel elements, the evaluation of prototype components used in the HWCTR (monitoring devices, control, and handling systems, construction materials, etc.), the accumulation of other information made available by the operation of the HWCTR (hydraulic performance, reactivity changes at high burnups, other physics information, etc.), the refinement of physics data using the PDP and pressurized exponential, the improvement of monitoring and hydraulic performance, and a concentrated study on means of reducing capital and operating costs.

Power reactor work after about fiscal year 1963 would depend to a large extent on the direction the Commission's power program takes. Lacking any guidance on this matter, we have assumed for planning purposes that the HWCTR, its loops, the pressurized exponential, fuel fabrication and test facilities, and engineering facilities will be called on to contribute further to the Commission's power program, particularly in the field of heavy water reactors.

Development manpower requirements

The total of power reactor and unassigned people shown gives a measure of the average effort that might be made available for nonproduction work.

Number of technical people

Development activity	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963	Fiscal year 1964	Fiscal year 1965
Power reactor work [1]	65	69	69	60	60	60
Unassigned based on fiscal year 1961 level			5	24	49	64
Total [2]	65	69	74	84	109	124

[1] These include the technical people required for the operation of the HWCTR but do not include the operating people required.

[2] This figure is an estimate of the number of people that could be profitably employed (other than on production support work) within the limitations of currently available laboratory facilities.

SAVANNAH RIVER LABORATORY RESOURCES

The Savannah River Laboratory is actually a complex of facilities located in three places on the Savannah River plant site. It includes facilities for conducting development work on all production operations.

The main laboratory building (773–A) contains facilities for bench-scale chemical, metallurgical, and instrument work, advanced types of chemical and metallurgical analyses, computations, chemical studies with intermediate radiation levels, chemical studies on materials with high-alpha levels, high-radiation level

[12] Material added from classified appendix.

chemical and metallurgical studies, chemical engineering and reactor studies, and metallurgical fabrication studies on a semiworks scale on a variety of materials. The building also houses most of the Laboratory's service facilities such as maintenance shops, technical information services, storerooms, glassblowing facilities, and design services. Close by the main laboratory building is the 774–A building where facilities are available for heat-treating large metal shapes, testing construction materials under high temperatures and pressures, and conducting fabrication studies using high-fluid pressures and temperatures.

The experimental physics facilities are located in another area. They consist of a large critical zero-power unit of great versatility and accuracy, a small graphite research pile of moderate power that provides a source of neutrons, a vessel atop this graphite pile that can be used for subcritical experiments, especially on reactor lattices, and a pressurized exponential unit that can be used to measure lattice characteristics at elevated temperatures and pressures.

The third Laboratory areas, referred to as CMX-TNX, is rather remote from other plant facilities. Its location was originally established in order to have it near the river for studies of cooling water. It contains facilities for full-scale studies of the hydraulic aspects of reactors and of chemical engineering devices used in separation processes.

The scientific people at the Savannah Laboratory number between 280 and 295. In addition a scientific staff group of about 20 people is located in Wilmington. This latter group takes care of liaison with subcontractors, and with the Process Section (who are responsible for new facilities). This staff group also provides an important independent, broad-view approach to research and development problems and to program evaluations. The number of people in this staff group would vary in response to changes in the magnitude of offsite interests. The scientific groups at the Laboratory are skilled in coordinating their efforts toward a common objective. Further, the groups are quite flexible in that people are frequently transferred between groups to meet unusual requirements in any particular field of work.

Some of the scientific people have had long experience in the atomic field, beginning as early as 1941. Others have had long and varied industrial experience prior to the beginning of the Savannah River project. A large number have been with the Savannah effort for 6 years or more. Over half have been trained in the fields of chemical engineering, physical chemistry, or physics, all of which are conducive to versatility. Their skills can be augmented as needed by drawing on the services of the works technical group, the works engineering group, and construction's forces.

Some of the fields in which the Laboratory staff is especially competent and experienced are the development and application of the technology of heavy water moderated reactors, the technology of heavy water production, the development of reactor fuel elements from metallurgy through reactor use, the development of control instrumentation, the development of mechanical and chemical engineering equipment, the development of advanced chemical analysis techniques, and the development of chemical processes for radiochemicals. In the case of chemical processes it is of interest to note that the Laboratory has been able to develop all such processes by establishing a flowsheet on a miniature, laboratory scale and testing the equipment cold on a pilot-plant or full-plant scale, that is, without the use of expensive hot semiworks facilities.

Both the facilities of the Savannah Laboratory and the experience of its staff are, in general, more suited to developing scientific data to fulfill specific needs and to translating scientific knowledge into practical applications than to advancing scientific frontiers.

NONPRODUCTION FIELDS

The following are some of the tasks in nonproduction fields, including power reactors, that might be undertaken by the Savannah River Laboratory and to which the experience and facilities of the Laboratory appear well suited. We attempted to estimate the manpower that might be required for each item but were not able to do so because a number of the items overlap and because the magnitude of effort that could be placed on some items is completely arbitrary. We believe, however, that between 100 and 300 technical men could be profitably employed on such work, depending on the desired magnitude of effort on certain items.

(*a*) The power reactor study in progress deals with systems moderated with heavy water and fueled with natural uranium. Reactors of this type currently

appear to be competitive with other types and have the advantages of using natural uranium fuel. Achieving power costs competitive with those from fossil fuels may well be a matter of critically studying and simplifying the individual components of a power reactor, including fuel elements. The resources of the Savannah Laboratory are well suited to such work, especially on the natural uranium-heavy water types.

The economy of future reactors also will depend, in part, on a fuller knowledge of the physics and engineering characteristics of materials. For example, the properties of moderators are not adequately known at high temperatures. Lighter but effective shielding is needed in special applications. Such information could be developed at the Savannah Laboratory.

The HWCTR or a specially modified version of another Laboratory development, the nuclear test gage, could be used for an experimental study of the effect of high burnups on the reactivity of individual fuel elements or assemblies. This is one of the darker corners of reactor technology.

(*b*) Experience has shown that the reactivties of natural uranium-heavy water reactors with wide lattice spacings cannot be predicted with a desirable degree of accuracy. Work is needed to establish more accurate basic data of kinds for which our large experimental apparatus is uniquely suitable. These include studies on resonance escape probabilities, reflector effects, delayed photoneutrons, ages of delayed neutrons, doppler coefficients, and spectral hardening.

(*c*) The Savannah production reactors are a unique source of neutron, neutrino, and gamma-ray fluxes. The HWCTR will provide similar fluxes in a test facility. Experiments requiring such fluxes for long periods and in relatively large equipment would be carried out. Such experiments in the HWCTR could include irradiations for scientific purposes for which production facilities were considered to be unsuitable because of the risk of shutdowns or a lack of adaptability.

The loop facilities that are being designed for the HWCTR could be modified to permit the circulation of materials that through pile activation would provide unusually high beta or gamma fields of unusually high energies for irradiation experiments adjacent to the reactor.

Such irradiation studies might include work in the fields of particle physics, induced reactions, construction materials development, the preservation of foods, and the sterilization or alteration of drugs and other articles of commerce.

(*d*) As time has passed, it has become increasingly apparent that a sore need in the nuclear field, especially as regards power reactors, is to find a way to alleviate dimensional instability under reactor conditions of natural and enriched fuel elements and other materials. This matter has an important bearing on the dimensional tolerance and burnup—hence on the economy—of fuel elements. An understanding of this problem may require quite a basic investigation of interstitial atoms in metallic lattices.

(*e*) The Savannah Laboratory is experienced in a number of processes for the fabrication of reactor components, especially in coextrusion, extrusion-cladding, fluid-pressure bonding, hot pressing, swaging, and roll-cladding, for which it has experimental equipment, some of which is unique. The country's knowledge of these techniques is highly empirical. Realizing the full advantages of such processes depends on having a better knowledge of their fundamentals. Perhaps the most rewarding field for investigation would turn out to be the flow of metals in the extrusion process. Extrusion-cladding is quite new as a process for producing high quality fuel elements, and many scientific and technical advances appear possible. These various processes also show signs of being applicable to nonmetallic or partially nonmetallic elements.

(*f*) The fuel-cycle cost for power reactor elements depends in part on the cost of chemically processing the spent elements. It seems likely that a fuller understanding of separation chemistry can lead to future processing plants that are much simpler. Advances in separation engineering are equally important in reducing the cost of future plants. For example, there is a possibility that centrifugal contactors of one sort or another will be able to perform extractions with low inventories and low equipment space requirements.

(*g*) The facilities of the Savannah Laboratory might be used to assist universities and hospitals in carrying out experiments and interpreting results from the use of radioelements in biochemistry, in biological tests, and in chemical reactions.

(*h*) The development of uses for fission products is a field in which a variety of types of scientific attention could be given.

Summer employment, training, and cooperative programs

SUMMER EMPLOYEES

Year	Savannah River laboratory				Savannah River plant (student graduate)
	Faculty		Student		
	High school	College	Graduate	Undergraduate	
1952	0	1	0	0	0
1953	0	1	0	0	0
1954	0	2	0	0	0
1955	0	2	6	0	1
1956	1	1	13	0	5
1957	3	2	11	1	4
1958	1	5	10	0	3

CLEMSON COOPERATIVE GRADUATE EDUCATIONAL PROGRAM

1958: 2 faculty (1 summer training; 1 18 months to 2 years training).
1959: 1 graduate (to report in June 1959).
Future: 1 or 2 graduates per year for a period of a few years.

ON-THE-JOB TRAINING PROGRAM

1957: 7 persons from Duquesne—worked in 100 area instruments; 1 person from South Carolina State Board of Health—worked in Building 735–A.
1958: 0.
1959: 1 person from PRDC—worked in 100 area instruments.

CO-OP PROGRAM

1956–58: 15 undergraduates—all worked in plant (4 to come onboard in 1959, 1 of 4 assigned to SRL) (1 of 15 has completed work and 1 of 15 dropped out of program).

Research and development plant authorized but not completed,[1] June 30, 1959

I. PROJECTS LOCATED AT THE 20 LABORATORIES DISCUSSED IN VOL. I

Project title	Estimated cost in thousands			
	Accelerators	Reactors	Other	Total
Ames Laboratory		$3,800	$2,619	$6,419
Metals process development plant				
Research reactor		3,800		
Facilities costing less than $1,000,000			719	
Argonne Cancer Research Hospital			50	50
Argonne National Laboratory	$31,398	38,087	34,002	103,487
National Reactor Testing Station, Idaho		31,403	434	31,837
Modifications to BORAX		1,530		
Fast power breeder (EBR II)		28,834		
Modifications to EBR I		1,000		
Facilities costing less than $1,000,000		39	434	
Lemont, Ill	31,398	6,684	33,568	71,650
Zero power reactor VI		3,000		
Fuels Technology Center			16,847	
Modifications to EBWR		1,810		
Zero gradient synchrotron	28,898			
General support installations expansion			4,300	
Chemistry hot laboratory			4,415	
Research and engineering reactor-design		1,000		
Van de Graaff accelerator	2,500			
Miscellaneous modifications and additions			1,000	
Facilities costing less than $1,000,000		874	7,006	

See footnotes at end of table, p. 153.

Research and development plant authorized but not completed,[1] June 30, 1959—Continued

Project title	Estimated cost in thousands			
	Accelerators	Reactors	Other	Total
Connecticut Aircraft Nuclear Engine Laboratory				None
Bettis Laboratory		$5,176	$7,166	$12,342
Pittsburgh, Pa.		2,999	6,664	9,663
Hot cells			2,000	
High temperature test installation		2,999		
Facilities costing less than $1,000,000			4,664	
National Reactor Testing Station, Idaho		2,177	502	2,679
Surface ship reactor facility		2,177		
Facilities costing less than $1,000,000			502	
Brookhaven National Laboratory	$27,480	10,975	16,966	55,421
High flux research reactor		10,000		
Physics building			3,300	
Engineering building			1,879	
Cosmotron target area	3,550			
Medical research plant and facilities			6,350	
Alternating gradient synchrotron	22,955			
Accelerator and reactor modifications	975	975		
High level radiation development laboratory			1,600	
Facilities costing less than $1,000,000			3,837	
Cambridge electronic accelerator: Particle accelerator program	11,517			11,517
Aircraft nuclear propulsion facility, Evendale; Evendale, Ohio:			23,017	23,017
Facilities costing less than $1,000,000			1,155	1,155
National Reactor Testing Station, Idaho			21,862	21,862
Modifications and additions, ANP ground test plant, and test area			21,659	
Facilities costing less than $1,000,000			203	
Hanford Laboratory		14,000	10,518	24,518
Plutonium Fabrication Pilot Plant			4,000	
Plutonium recycle experimental reactor		14,000		
Improvements to supporting installations			2,748	
Facilities costing less than $1,000,000			3,770	
Knolls Atomic Power Laboratory		53,723	2,751	56,474
Destroyer reactor plant		35,000		
Natural circulation test plant		18,500		
Facilities costing less than $1,000,000		223	2,751	
Lawrence Radiation Laboratory	6,257		46,197	52,454
Berkeley, Calif.	6,257		10,166	16,423
Accelerator improvements	1,298			
Cyclotron	4,600			
Chemistry building addition			2,000	
Engineering service building			1,188	
Physics building			2,000	
Facilities costing less than $1,000,000	359		4,978	
Livermore, Calif.			36,031	35,031
High explosive development plant			4,016	
Weapons development and engineering facilities			3,978	
Metallurgy laboratory			2,270	
Test installations for classified projects			9,792	
Research facilities			3,019	
Weapons production and development plants			6,764	
Controlled thermonuclear facilities			1,400	
Facilities costing less than $1,000,000			4,792	
Los Alamos Scientific Laboratory			22,727	22,827
Phermex installation			3,550	
Research and development test plant			4,287	
Power reactor development acceleration project			1,812	
Hot cells			1,850	
Facilities costing less than $1,000,000			11,328	

See footnotes at end of table, p. 153.

Research and development plant authorized but not completed,[1] June 30, 1959—Continued

Project title	Estimated cost in thousands			
	Accelerators	Reactors	Other	Total
Oak Ridge National Laboratory	$5,585		$39,384	$44,969
Plant modifications for processing nonproduction spent fuels			1,250	
Reprocessing pilot plant			3,463	
Hot cells			2,940	
Controlled thermonuclear facilities			1,584	
Metals and ceramics research building			6,500	
Permanent research buildings			5,488	
Central research laboratory addition			3,054	
Cyclotron	3,000			
Transuranium laboratory			1,200	
10 Mev. tandem Van de Graaff accelerator	2,400			
Radioisotope process development laboratory			1,500	
Facilities costing less than $1,000,000	185		12,405	
Oak Ridge Institute of Nuclear Studies: Facilities costing less than $1,000,000			245	245
Princeton-Pennsylvania accelerator	11,206			11,206
Model C stellarator: Controlled thermonuclear facilities			9,929	9,929
Sandia Laboratory		$3,200	13,385	16,585
Albuquerque		3,200	12,549	15,749
Test and environmental installations			2,488	
Reactor, area III, Sandia base		3,200		
Weapons production and development plants			5,021	
Facilities costing less than $1,000,000			5,040	
Livermore: Facilities costing less than $1,000,000			836	836
Savannah River Works Laboratory		9,300	697	9,997
Heavy water component test reactor		9,300		
Facilities costing less than $1,000,000			697	
University of Rochester: Facilities costing less than $1,000,000			543	543
Total, laboratories	93,443	138,261	230,296	462,000

II. OTHER LOCATIONS

Phillips Petroleum Co., National Reactor Testing Station		15,875	22,875	38,750
Army reactor experimental area			1,000	
Waste calcination system			6,000	
Hot pilot plant			2,000	
Addition to electrical power system			1,293	
Portable gas-cooled reactor prototype		2,875		
Plant modifications for processing nonproduction spent fuels			1,450	
New waste storage installation			3,200	
Alterations, modifications, and additions to MRT-ETR facilities		2,000		
Nuclear test plant, area		5,000		
Experimental organic cooled reactor		6,000		
Facilities costing less than $1,000,000			7,932	
Idaho operations office Design and engineering studies of 2 large-scale power reactors and 1 intermediate size prototype		[3] 700		700
Atomics International		7,219	1,678	8,897
Idaho: Facilities costing less than $1,000,000		219		219
Canoga Park		7,000	1,678	8,678
Special-purpose test installation		2,300		
Sodium reactor experiment modifications		4,700		
Facilities costing less than $1,000,000			1,678	
Combustion engineering		13,763		13,763
Small submarine reactor test facilities		13,500		
Facilities costing less than $1,000,000		263		

See footnotes at end of table, p. 153.

***Research and development plant authorized but not completed,[1] June 30, 1959*—Continued**

Project title	Estimated cost in thousands			
	Accelerators	Reactors	Other	Total
Chicago Operations Office: Design and engineering studies of two large-scale power reactors		[2] $1,500		$1,500
Elk River reactor		9,397		9,397
Hallam nuclear power facility		24,013		24,013
Nevada test site			$16,771	16,771
Fast reactor safety testing station			1,367	
Research and development test plant			9,291	
Modifications and additions for test installation, Pluto			1,525	
Research and development test plant additions and modifications, Rover			3,360	
Facilities costing less than $1,000,000			1,228	
Merchant ship reactor		26,250		26,250
City of Piqua reactor		7,332		7,332
Shippingport pressurized water reactor		6,809		6,809
Savannah River Operations Office: Design and engineering study of heavy water moderated power reactor		[2] 1,500		1,500
Oak Ridge Operations Office		30,300	215	30,515
Gas cooled power reactor		30,000		
Facilities costing less than $1,000,000		[2] 300	215	
Army package power reactor No. 2		3,000		3,000
Puerto Rico Nuclear Center		3,000	3,650	6,650
Power reactor capable of utilizing nuclear superheat		3,000		
Nuclear training project			3,000	
Facilities costing less than $1,000,000			650	
Various locations		46,056	3,908	49,964
Modifications to OMRE, EBWR, and BORAX (not allocated)		1,760		
Cooperative power reactor demonstration program		9,349		
Design and engineering studies of 2 large-scale power reactors and 1 intermediate size prototype		[2] 3,800		
IAEA research reactors and laboratory grant		2,000		
Cooperative power reactor demonstration program		25,000		
Installations for biomedical research projects			1,368	
Experimental low temperature process heat reactor		4,000		
Facilities costing less than $1,000,000		147	2,540	
Total research and development	$93,443	334,975	279,393	707,811

[1] Projects estimated to cost $1,000,000 or more are listed separately; others are grouped. Equipment items are grouped with facilities costing less than $1,000,000. In some cases, discrete portions of these projects have been completed and are carried in the completed plant accounts.

[2] Design studies included in reactors column are:

Idaho Operations Office	$700
Chicago Operations Office	1,500
Savannah River Operations Office	1,500
Oak Ridge Operations Office	300
Undesignated	3,800
Total	7,800

APPENDIX II

MATERIAL RELATING TO THE PREPARATION OF THE PRECEDING REPORT AND SUBSEQUENT SOLICITATION OF COMMENTS ON THE REPORT

JCAE Letter Dated March 15, 1960, Soliciting Comments on the Future Role of the AEC Laboratories

Congress of the United States,
Joint Committee on Atomic Energy,
March 15, 1960.

The Joint Committee, in its consideration of the future role of AEC laboratories, asked the Commission in June of 1959 to prepare a report on its present and projected plans for the laboratories. A copy of the report prepared by the Commission in response to this request is attached.

The Joint Committee is sending a copy of the Commission's report to industry, university, and Government personnel to obtain their comments on the report and to elicit their views in general on the future role of the AEC laboratories.

In this connection we would appreciate receiving your comments and views on the subjects covered in the attached report. In addition to any other items you wish to cover, we would appreciate receiving your comments and views on the specific statements in the Commission report referred to on the attached sheet.

It is our intent to publish as a committee print the attached report and the comments received. We would appreciate receiving your comments by April 30, 1960.

Sincerely yours,

James T. Ramey, *Executive Director.*

Specific Items in the Commission's Report on "The Future Role of AEC Laboratories" Dated February 1960, Concerning Which Comments are Requested

1. The future role of Commission laboratories by class, pages 6–9, volume I.
2. Policies for Commission cooperation with universities and industry, pages 9–17, volume I.
3. Research and development objectives of the Commission laboratories, pages 13–26, volume I.
4. Estimates of changes in work and level of effort in Commission research and development programs, pages 27–63, volume I.
5. Future facility addition and replacement plans at Commission laboratories.
6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories, page 66, volume I.
7. Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary, page 67, volume I.
8. (*a*) Planned changes in staff and program emphasis at each of the Commission laboratories, volume I, part II, starting on page 71.

(*b*) Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity.

(*c*) Whether greater emphasis should be given to more advanced nuclear research and development projects.

(*d*) Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories.

[No. 261. From the Office of the Joint Committee on Atomic Energy. For release Thursday, Mar. 17, 1960]

AEC Report on Role of AEC National Laboratories and Other Major Laboratory Installations

Atomic Energy Commission plans for the next decade for its 20 laboratories were made public today through the release of an AEC report on the future roles of the laboratories by Senator Clinton P. Anderson (Democrat, New Mexico), chairman of the Joint Committee on Atomic Energy, and Representative Melvin Price (Democrat, Illinois), chairman of its Subcommittee on Research and Development. The Commission performed the study of its laboratories in compliance with a request from the Joint Committee in June 1959.

AEC laboratories now employ approximately 42,000 people, with a present annual operating budget of approximately two-thirds of a billion dollars, excluding expenditures for weapons work.

Senator Anderson and Congressman Price stated that the Joint Committee considers the formulation of sound plans for the future role of the Government's atomic energy laboratories to be of vital importance to the Nation. In summarizing the past accomplishments of the Commission's laboratories and future scientific challenges, they stated:

"We owe our very existence as a nation to the past work of our atomic energy laboratories. Their work over the past 20 years has made us first and foremost in the field of atomic weapons. The work of our atomic laboratories has also placed us in a leading position relative to the peaceful uses of atomic energy. Our international competition has increased and therefore we must carefully plan and vigorously support our atomic development work for the future to retain our position in this vital field of research."

The Joint Committee has sent copies of the report to industry, university, and Government personnel and has requested comments and views on the report and views on what the future role of the laboratories should be. Replies have been requested by April 15, 1960. After all comments are received the Joint Committee intends to publish both the Commission report and the comments received as a committee print.

The letter sent to industry, university, and Government representatives requesting comments on the Commission's report on the future role of the atomic energy laboratories specifically asked for comments on the following areas of the Commission's plans:

(1) The types of research work which should be performed by the laboratories;

(2) Policies for Commission laboratories' cooperation with industry and educational institutions; and

(3) Plans for future increases and decreases in effort at each of the Commission laboratories.

In announcing the committee's effort to solicit comments concerning future plans for the Commission's laboratories, Senator Anderson stated the following:

"Numerous public and private comments have been made in the past few months concerning the future role of the Government's atomic energy laboratories. Unfortunately many of these comments were made without concrete knowledge of the actual facts involved in the research and development work of our laboratories. As a result, I fear some misunderstanding has been generated on such issues as alleged unjustified competition between AEC and private laboratories.

"I believe the Commission's report on the laboratories together with their earlier reply to specific questions[1] has clarified the role of AEC laboratories considerably."

The Commission report consists of two volumes. The first volume contains the Commission's analysis and conclusions concerning the role of the labora-

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[1] See AEC release No. C–23, dated Feb. 12, 1960, containing letters to Chamber of Commerce of the United States, National Association of Manufacturers, and the Manufacturing Chemists' Association, Inc.

tories for the next decade. The second volume contains the long range program statements as prepared by the Commission's laboratories and a list of research and development facilities authorized for the laboratories but not yet completed.

A few extra copies of the Commission's report are available in the Joint Committee Office, Room F–88, of the Capitol.

The committee staff has prepared the attached brief two-page summary of the Commission's report.

SUMMARY OF THE COMMISSION REPORT ON THE FUTURE ROLE OF AEC LABORATORIES, DATED FEBRUARY 1960

(Prepared by Joint Committee on Atomic Energy Staff)

SUMMARY AND CONCLUSIONS

1. The voume of AEC research and development work will increase during the next 10 years.

2. Capacity for the performance of new projects at the laboratories will be made available by removing work which has been brought to the point where it can be carried on by others.

3. Commission laboratories will remain paramount in pioneering work as the inventors and developers of new concepts but increased responsibility will continue to be placed on industrial organizations as they acquire facilities and capabilities.

4. It is intended to keep the weapons development laboratories strong. If a decrease in weapons work develops, consideration will be given to expanding nonweapons work in such laboratories.

FUTURE ROLE OF INDIVIDUAL MAJOR LABORATORIES

Argonne National Laboratory, Lemont, Ill.—A moderate expansion of the staff is contemplated (present total, 3,600).

Brookhaven National Laboratory, Long Island, N.Y.—A substantial expansion of effort is anticipated (present total, 1,800).

Oak Ridge National Laboratory, Oak Ridge, Tenn.—The staff will remain generally stable during the next 10 years (present total, 5,000).

Ames Laboratory, Ames, Iowa.—A quite modest total increase is anticipated over the coming 10 years (present total, 423).

Lawrence Radiation Laboratory, Berkeley, Calif.—A major increase in staff strength by the end of the 10-year period is envisioned (present total, 2,200).

Lawrence Radiation Laboratory, Livermore, Calif.—A slight increase in Pluto work (atmospheric rocket) is foreseen. Future increases in Plowshare work may occur (present total, 3,600).

Los Alamos Scientific Laboratory, Los Alamos, N. Mex.—A slow and limited growth may occur if weapons work continues and other anticipated projects develop (present total, 4,070).

Aircraft nuclear propulsion facility, Evendale, Ohio.—The current level appears appropriate (present total, 2,930).

Bettis Laboratory, Pittsburgh, Pa.—The personnel cutback from the high of nearly 5,000 will continue until a stabilized level, somewhat below 3,000, is reached (present total, 3,600).

Aircraft nuclear propulsion facility, Hartford, Conn.—An upward trend in activity is expected to continue through fiscal year 1961, after which a stable level should be maintained. An increase would be required in the mid-1960's if a ground test prototype is to be built (present total, 1,600).

Knolls Atomic Power Laboratory, Schenectady, N.Y.—The size of the staff is expected to remain at its present level (present total, 2,180).

Sandia Laboratory, Albuquerque, N. Mex.—Present personnel level expected to be maintained for early future years. The period following is dependent upon the required weapons program and other work which may be assigned to the Laboratory (present total, 7,940).

Hanford Laboratory, Richland, Wash.—Plutonium production manpower may be reduced. Reactor development and radiation biological work is expected to increase (present total, 1,670).

Savannah River Laboratory, Aiken, S.C.—Production support work will decrease. New assignments, particularly in the reactor development field, will result in a generally stable effort by the Laboratory as a whole (present total, 635).

COMPLETE LIST OF ADDRESSES SOLICITED

INDUSTRY

Aerojet General Corp., 6352 North Irwindale Avenue, Azusa, Calif.: Mr. Dan A. Kimball, president.

Alco Products, Inc., 1 Knott Street, Schenectady, N.Y.: Mr. W. D. Leggett, Jr., vice president, engineering.

Allis-Chalmers Manufacturing Co., 1953 Thomas Street, Milwaukee, Wis.: Mr. R. M. Casper, general manager, Nuclear Power Division.

American Radiator & Standard Sanitary Corp., 40 West 40th Street, New York, N.Y.: Mr. John C. Linsenmeyer, executive vice president.

Armour Research Foundation, Illinois Institute of Technology, 3440 South State Street, Chicago, Ill.: Dr. Leonard Reiffel, manager, Physics Research Department.

Associated Nucleonics, Inc., Garden City, N.Y.: Mr. W. E. Kelley, president.

Atomics International, Post Office Box 309, Canoga Park, Calif.: Dr. Chauncey Starr, president.

Babcock & Wilcox Co., 161 East 42d Street, New York, N.Y.: Mr. L. M. Currie, vice president, Atomic Energy Division.

Babcock & Wilcox Co., 161 East 42d Street, New York, N.Y.: Mr. W. T. Moore, manager, Atomic Energy Division.

Baker & Co., Inc., Division of Englehardt Industries, 113 Astor Street, Newark, N.J.: Mr. L. C. Burman.

Bechtel Corp., 220 Bush Street, San Francisco, Calif.: Mr. J. P. Yates, executive vice president.

Battelle Memorial Institute, Mr. B. D. Thomas, president, Columbus, Ohio.

Burns & Roe, Inc., 160 West Broadway, New York, N.Y.: Mr. Ralph C. Roe, president.

California Research Corp., 576 Standard Avenue, Richmond, Calif.: Dr. Donald E. Hull.

Carborundum Metals Corp., Post Office Box 32, Akron, N.Y.: Mr. N. C. Bartholomew, vice president and general manager.

Columbia National Corp., 70 Memorial Drive, Cambridge, Mass.: Mr. Gordon Kiddoo, vice president and general manager.

Combustion Engineering, Inc., Prospect Hill Road, Windsor, Conn.: Dr. Walter H. Zinn, vice president.

Commonwealth Edison Co., 72 West Adams Street, Chicago, Ill.: Mr. Willis Gale, chairman.

Consolidated Edison Co., of New York, Inc., 4 Irving Place, New York, N.Y.: Mr. James F. Fairman, senior vice president.

Consumers Public Power District, Columbus, Nebr.: Mr. Roy Schacht, general manager.

Curtiss-Wright Corp., 50 Rockefeller Plaza, New York, N.Y.: Mr. Roy T. Hurley, president.

Davison Chemical Co., 101 North Charles Street, Baltimore, Md.: Mr. T. C. Runion, general manager, reactor materials.

Denver & Rio Grande Western Railroad Co., Post Office Box 5482, Denver, Colo.: Mr. Ray McBrian, director of research.

Ebasco Services, Inc., 2 Rector Street, New York, N.Y.: Mr. Frederick C. Gardner, president.

Esso Research & Engineering Co., Post Office Box 51, Linden, N.J.: Mr. H. L. Yowell, project manager.

Evans Research & Development Corp., 250 East 43d Street, New York, N.Y.: Mr. Eric J. Hewitt, vice president of research.

H. K. Ferguson Co., 1783 East 11th Street, Cleveland, Ohio: Mr. W. N. Thompson, president.

Fluor Corp., Ltd., Atlantic and Thomas Boulevard, Los Angeles, Calif.: Mr. J. Simon Fluor, president.

Ford Instrument Co., 31–10 Thomas Avenue, Long Island, N.Y.: Mr. Charles Rockwell, president and general manager.

General Atomics Division, General Dynamics Corp., Post Office Box 608, San Diego, Calif.: Mr. Frederick de Hoffman, vice president.

General Motors Corp., Post Office Box 188, North End Station, Detroit, Mich.: Dr. Alexander Somerville, supervisor of Physics Department, Research Laboratory Division.

Industrial Nucleonics, 1205 Chesapeake Avenue, Columbus, Ohio: Mr. George Foster.

Industrial Testing Reactors, Inc., 401 Addison Building, Charlotte, N.C.: Mr. H. Haywood Robbins.
Kaiser Engineering Corp., 1925 Broadway, Oakland, Calif.: Mr. David F. Shaw, vice president.
Arthur D. Little, Inc., 3000 Memorial Drive, Cambridge, Mass.: Mr. Michael Michaelis.
Lockheed Aircraft Corp., Burbank, Calif.: Mr. Courtlandt S. Gross, president.
Mallinckrodt Chemical Works, 2d and Mallinckrodt, St. Louis, Mo.: Mr. Harold E. Thayer.
The Martin Co., Baltimore, Md.: Mr. J. Donald Rauth, vice president.
Mallory Sharon Metals Corp., Niles, Ohio: Mr. F. H. Vandenburgh, president.
McLain Rodger Associates, Mr. Stuart McClain, 921 60th Place, Downers Grove, Ill.
Michigan Chemical Corp., St. Louis, Mich.: Mr. Theodore Marvin, president.
Nuclear-Chicago Corp., 223 West Erie Street, Chicago, Ill.: Mr. James M. Phelan.
Nuclear Development Corp. of America, 5 New Street, White Plains, N.Y.: Mr. John R. Menke.
Nuclear Materials & Equipment Corp., Apollo, Pa.: Dr. Zalma M. Shapiro.
Nuclear Science & Engineering Corp., Post Office Box 1091, Pittsburgh, Pa.; Mr. Ronald A. Brightsen.
Olin Mathieson Chemical Corp., New Haven, Conn.: Mr. Ted Hartshorne, vice president, Nuclear Division.
Phillips Petroleum Co., Atomic Energy Division, Idaho Falls, Idaho: Mr. Richard L. Doan, manager.
Power Reactor Development Co., 2000 Second Avenue, Detroit, Mich.: Mr. Walker Cisler, president.
Radiation Counter Laboratories, Inc., Skokie, Ill.: Dr. Ernest H. Wakefield, president.
Radiation Dynamics, Inc., Westbury Industrial Park, Westbury, Long Island, N.Y.: Dr. Kennard H. Morganstern, president.
Sargent & Lundy, 140 South Dearborn Street, Chicago, Ill.: Mr. Alf Kolflat.
Stone & Webster Engineering Corp., 49 Federal Street, Boston, Mass.: Mr. F. W. Argue.
Sylvania-Corning Nuclear Corp., Bayside, Long Island, N.Y.: Dr. Lee Davenport, president.
Texas Instruments, Inc., 100 Exchange Park, Dallas, Tex.: Mr. P. E. Haggerty, president.
Tracerlab, Inc., 1601 Trapelo Road, Waltham, Mass.: Mr. Homer Meyers.
Vitro Corp. of America, 261 Madison Avenue, New York, N.Y.: Mr. Norman A. Spector, vice president.
Westinghouse Electric Corp., 3 Gateway Center, Pittsburgh, Pa.: Mr. Charles H. Weaver, vice president.
Yankee Atomic Electric Co., 441 Stuart Street, Boston, Mass.: Mr. William Webster, president.

EDUCATIONAL INSTITUTIONS

Amherst College, Amherst, Mass.: Mr. Charles W. Cole, president.
Associated Midwest Universities, Box 307, Lemont, Ill.: Dr. John Roberson, executive director.
Associated Universities, Inc., 10 Columbus Circle, New York, N.Y.: Dr. Lloyd Berkner, president.
California Institute of Technology, Pasadena, Calif.: Dr. Lee A. DuBridge, president.
California, University of, Berkeley, Calif.: Dr. G. T. Seaborg, chancellor.
Carnegie Institute of Technology, Pittsburgh, Pa.: Dr. John C. Warner, president.
Colorado, University of, Boulder, Colo.: Dr. Quigg Newton, president.
Chicago, University of, Chicago, Ill.: Dr. L. Kimpton, chancellor.
Columbia University, New York, N.Y.: Dr. Grayson Kirk, president.
Georgia Institute of Technology, Atlanta, Ga.: Dr. Edwin D. Harrison, president.
Harvard University, Cambridge, Mass.: Dr. Nathan M. Pusey, president.
Idaho, University of, Moscow, Idaho: Dr. D. R. Theophilus, president.
Illinois, University of, Urbana, Ill.: Dr. David D. Henry, president.
Iowa State University, Ames, Iowa: Mr. James H. Hilton, president.
Massachusetts Institute of Technology, Cambridge, Mass.: Dr. Julius A. Stratton, acting president.
Midwest Universities Research Association, 2203 University Avenue, Madison, Wis.: Dr. M. W. Keith.
Michigan, University of, Ann Arbor, Mich.: Dr. Harlan Hatcher, president.

Minnesota, University of, Minneapolis, Minn.: Dr. James L. Morrill, president.
New Mexico, University of, Albuquerque, N. Mex.: Mr. Tom L. Popejoy, president.
North Carolina, University of, Raleigh, N.C.: Dr. William Friday, president.
Notre Dame, University of, South Bend, Ind.: Rev. T. M. Hesburgh, president.
Ohio State University, Columbus, Ohio: Dr. Novice Fawcett, president.
Pennsylvania State University, University Park, Pa.: Dr. Eric A. Walker, president.
Pennsylvania, University of, Philadelphia, Pa.: Dr. Gaylord P. Harnwell, president.
Princeton University, Princeton, N.J.: Dr. Henry D. Smyth, chairman of board of scientific and engineering research.
Purdue University, Lafayette, Ind.: Dr. Paul F. Chenea, head, division of engineering services.
Reed College, Portland, Oreg.: Dr. Richard H. Sullivan, president.
Rensselaer Polytechnic Institute, Troy, N.Y.: Dean V. L. Parsegian, School of Engineering.
Rochester, University of, Rochester, N.Y.: Dr. Cornelis W. deKiewiet, president.
Stanford University, Stanford, Calif.: Dr. J. E. Wallace Sterling, president.
Tennessee, University of, Knoxville, Tenn.: Dr. Andrew Holt, president.
Washington, University of, Seattle, Wash.: Dr. Charles E. Odegaard, president.
Wisconsin, University of, Madison, Wis.: Dr. Conrad A. Elvehjem, president.

AEC LABORATORIES

ANP: Mr. S. J. Levine, acting general manager, General Electric Co., Aircraft Nuclear Propulsion Division, Post Office Box 132, Cincinnati 15, Ohio.
Ames: Dr. Frank H. Spedding, director, Ames Laboratory, Iowa State College, Ames, Iowa.
Argonne: Dr. Leon O. Jacobson, director, Argonne Cancer Research Hospital, University of Chicago, Chicago, Ill.
ANL: Dr. Norman Hilberry, Director, Argonne National Laboratory, Lemont, Ill.
Bettis: Mr. Phillip N. Ross, general manager, Bettis Atomic Power Laboratory, Westinghouse Electric Corp., Pittsburgh, Pa.
Brookhaven: Dr. Leland J. Haworth, Director, Brookhaven National Laboratory, Upton, Long Island, N.Y.
Canel: Mr. B. A. Schmickrath, manager, Connecticut Aircraft Nuclear Engine Laboratory, Pratt & Whitney, Hartford, Conn.
Cambridge electron accelerator: Dr. M. Stanley Livingston, director, Cambridge electron accelerator, Harvard University, Oxford Street, Cambridge, Mass.
Hanford: Mr. W. E. Johnson, General Manager, Hanford atomic production operation, General Electric Co., Richland, Wash.
Knolls (KAPL): Mr. B. H. Caldwell, Jr., general manager, Knolls Atomic Power Laboratory, Schenectady, N.Y.
Lawrence: Dr. Edwin M. McMillan, Director, Lawrence Radiation Laboratory, Berkeley, Calif.
LASL: Dr. Norris E. Bradbury, Director, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
ORINS: Dr. Paul M. Gross, President, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.
ORNL: Dr. Alvin M. Weinberg, Director, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Rochester: Dr. Henry A. Blair, director, AEC biomedical project, University of Rochester, Rochester, N.Y.
Sandia: Dr. Julius P. Molnar, President, Sandia Laboratory, Sandia Base, Albuquerque, N. Mex.

OTHER INTERESTED GROUPS

AFL–CIO: Mr. Andrew J. Biemiller, director, department of legislation, AFL–CIO, 815 16th Street NW., Washington, D.C.
AIF: Mr. Charles Robbins, Atomic Industrial Forum, 3 East 54th Street, New York, N.Y.
APPA: Mr. James L. Grahl, Atomic Energy Committee, American Public Power Association, 919 18th Street NW., Washington, D.C.

EEI: Mr. Elmer L. Lindseth, chairman, Committee on Atomic Power, Edison Electric Institute, 75 Public Square, Cleveland, Ohio.

NAM: Mr. James F. Fairman, chairman, Nuclear Energy Committee, National Association of Manufacturers, 2 East 48th Street, New York, N.Y.

NICB: Mr. John S. Sinclair, president, National Industrial Conference Board, 460 Park Avenue, New York, N.Y.

NRECA: Mr. Clyde T. Ellis, executive manager, National Rural Electric Cooperative Association, 1303 New Hampshire Avenue NW., Washington, D.C.

Manufacturing chemists: Mr. John E. Hull, president, Manufacturing Chemists' Association, Inc., Universal Building, 1825 Connecticut Avenue NW., Washington, D.C.; and Dr. R. C. Johnson, Manufacturing Chemists' Association, Inc., Universal Building, 1825 Connecticut Avenue NW., Washington, D.C.

Nucleonics: Mr. Jerome Luntz, editor, 330 West 42d Street, New York, N.Y.

Rural co-op: Mr. O. N. Gravegaard, president, board of directors, Rural Cooperative Power Associates, Elk River, Minn.

U.S. Chamber of Commerce: Mr. Clarence Miles, manager, Legislative Department, U.S. Chamber of Commerce, 1615 H Street NW., Washington, D.C. Also, Copies delivered to Len Lederman of Chamber of Commerce for their committee on role of labs., March 17, for following:

1. Big Chief Milling Co.
2. Powers (of Purdue).
3. Southern Co.
4. General Foods.
5. Arthur V. Peterson.
6. National Lead Co.

STATE AND FEDERAL AGENCIES

Dr. G. B. Kistiakowski, Chairman, the President's Science Advisory Committee, The White House, Washington, D.C.

Dr. Warren C. Johnson, Chairman, General Advisory Committee to the U.S. Atomic Energy Commission, Washington, D.C.

California: Col. Alexander Grendon, coordinator for atomic energy development and radiation protection, State House, Sacramento, Calif.

New York:

Mr. Oliver Townsend, atomic energy coordinator, State of New York, 20 West 55th Street, New York, N.Y.

Major General Thomas F. Farrell, Power Authority of the State of New York, the Coliseum Tower, 10 Columbus Circle, New York, N.Y.

National Science Foundation, Mr. Alan T. Waterman, Director, 1951 Constitution Avenue NW., Washington, D.C.

Oregon: Dr. Eugene C. Starr, U.S. Department of the Interior, Bonneville Power Administration, Portland, Oreg.

Tennessee: Mr. Herbert D. Vogel, Chairman of the Board, Tennessee Valley Authority, Knoxville, Tenn.

APPENDIX III

COMMENTS RECEIVED FROM INDUSTRY

AEROJET-GENERAL CORP.,
Azusa, Calif., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, U.S. Capitol Building, Washington, D.C.

DEAR MR. RAMEY: Aerojet-General Corp. is pleased to provide you its comments and suggestions for the future role of the Atomic Energy Commission laboratories. We have examined the Commission reports. The policies stated are excellent and well considered. The meaningfulness of the policies will be determined, however, by the way they are implemented in the next decade.

The Commission report points out on page 19 that the pace of application of basic knowledge has accelerated enormously from that of the last century. Nearly two generations elapsed between the discovery of electromagnetic induction and the completion of the first electric generating station. Less than half a decade elapsed between the discovery of fission and use of the atomic bomb. Even less time has elapsed between the invention of the transistor and its commercial application. To continue the rapid application of new ideas soon after their conception requires that the same individuals and organizations which do the basic research, participate in the advanced stages of practical application.

The Government has a well-established policy of placing procurement from industry—for basic research, hardware and services—on a competitive free-enterprise basis. With this policy the Government has achieved remarkable technological advances and built a strong scientific and engineering capability for the United States. Under this policy, those industrial organizations contributing to the general advancement have prospered, and those less successful have withered. The industrial research and development laboratories have achieved the highest standards of scientific competence, equal to that of the AEC and other Government-supported laboratories. Scientists and engineers of industrial laboratories have won honors ranging from Nobel Prizes to memberships in the National Academy of Sciences and fellowships in the national professional societies.

For these reasons, the policy of considered expansion of the Commission laboratories and the transfer of programs to industrial laboratories, as discussed in pages 63 through 69 of the report, should be implemented by establishing the practice of allowing industrial laboratories the opportunity to freely compete for research and development programs as well as hardware developments which under current practices would be assigned to the Commission laboratories by administrative directive. Competition would be a stimulant to both types of institutions and by itself would implement the policy recommended by the Commission.

Under such a system of free competition, the growth of industrial research and development laboratories, Commission laboratories, other Government-supported institutions, and university laboratories may be expected to be carried out to the greatest benefit of the Nation as a whole.

No strong and well-qualified institution could logically refute the merits of this approach to building a stronger national capability.

Thank you for the opportunity to express our views on this matter.

Very truly yours.

DAN A. KIMBALL, *President.*

ALCO PRODUCTS, INC.,
Schenectady, N.Y., April 25, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you very much for the opportunity to comment on the Commission's report on the future role of its laboratories. I find this a very thoughtful study and one which I am not inclined to attempt to take apart in detail. At the same time the rate of expansion which has occurred over the last 8 years and is contemplated for the 1960's even though at a lower rate, is one which should be a matter of concern to anyone having to do with the administration of atomic energy.

Any Government department, bureau, or commission having the responsibility for the expenditure of Government funds should have an adequate technical and supporting laboratory to determine, insofar as possible, that these expenditures are being wisely made in the best interests of the public. The Atomic Energy Commission certainly falls in this category and in its very early stage of growth probably should maintain a higher than normal proportion of laboratories. This, however, is an exceedingly difficult ratio to fix. Both Government and private laboratories are desirable. Much of the work could be done in either. There is a tendency always on the part of people handling a job to put it where they have the maximum control over it and in a Government organization this always tends to favor the Government-controlled laboratory.

On the other hand the Government-controlled laboratories are equipped in a manner which can seldom be justified by a privately owned industrial laboratory, It is in the interest of the country that these facilities once provided be used. It is, of course, axiomatic that these facilities having been provided should be staffed adequately both as to numbers and quality of personnel.

Personnel constitute a major problem. Because of the greater remunerations and greater freedom of action there is a tendency for the more talented scientists and engineers to find their way into industry. This mitigates against doing the most imaginative job possible in basic research for which the Government laboratories are generally better equipped than private industry. This is overcome to some extent by committees, consultants, the use of college and university staffs. There are, of course, also many dedicated men in Government laboratories who do stay because of their interest in the work. In any event it appears that as a Nation we shall be dependent to a large extent in the atomic energy field for the Commission's laboratories for a major portion of our basic research work for some years to come.

The greater danger in Government laboratories lies in the field of applied research and engineering development. Here the practical features of production engineering, cost evaluation, etc., begin to enter and these factors are generally coped with more understandingly by the engineering and development staffs of industrial concerns.

In the area of engineering development which constitutes the bulk of the work performed in all research and development operations, there is a very real danger of expanding Government laboratories beyond the optimum point. This appears to be a situation which is appreciated in the Commission's report but is one which should be a matter of particular interest to the Joint Committee. A review of this category of work and a running comparison between what goes into Government laboratories and into industrial concerns is probably maintained by the committee. If it is not, such a figure would certainly be of interest and only by consistent pressure on the side of putting work into industrial laboratories can this ratio be maintained.

The Commission's laboratories, with which I am familiar, are well run and well staffed operations. I think that they are necessary to the sound operation of the Commission. I think they constitute the only avenue through which much essential research and development activity can be accomplished. At the same time it is important that industrial research and development laboratories be fostered, and made to grow at a rate equal to or exceeding the Government-owned laboratories.

Very truly yours,

W. D. LEGGETT, Jr.,
Vice President—Engineering.

ARMOUR RESEARCH FOUNDATION OF
ILLINOIS INSTITUTE OF TECHNOLOGY,
Chicago, Ill., May 10, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I am pleased to have the opportunity to comment on the report by the Atomic Energy Commission concerning the future role of the AEC laboratories. I cannot, of course, treat many matters discussed therein with great specificity. On the other hand, I can state that I feel in general agreement with the R and D objectives as described in pages 13 to 26 of the report.

Furthermore, I am happy to see a statement on page 66 that the AEC will support greater increases in basic research at universities. This, to me, is a most healthy trend as long as the role of the universities is not much further distorted in a manner detrimental to their role as teaching institutions.

On page 65 the Commission notes that it is becoming more possible to turn to industry and to the universities. I have not felt that the Commission views the incorporation of industry into its research programs (as distinguished from routine hardware procurement) as an urgent matter. I have earnestly sought, but have not found, many occasions where the Commission has evidenced a real sense of obligation to expand industry's capability, perhaps at the temporary expense of its own activities. I think that the major reasons for this low emphasis on industrial participation are those outlined on page 108 of the second volume, "Supplementary Materials." For the reasons listed and occasionally for others too, such as the altogether human tendency to "empire build," I do not believe there is a widespread and genuine desire to go "outside." It is most assuredly true that there are grave difficulties in employing facilities outside of the Commission laboratories. On the other hand, the long-range benefits that might be enjoyed by increased participation and contact between the Commission laboratories and the industrial complex can hardly be overestimated. Technical leadtime would presumably be reduced, the economy strengthened, and the technology broadened. These benefits, unfortunately, tend to be diffuse and hard to identify, while the detriments of temporary inefficiency, cumbersome problems of administration, and "loss of control" are all specific, urgent, personal, and all too readily identifiable. It thus appears clear to me that strong external forces must be brought to bear to compensate for the difference in character between the benefits and detriments arising out of increased outside participation in Commission programs. The outside forces cannot be expected to develop in the laboratories themselves but must, I believe, come from the Commission, from the Congress, or from industry itself.

Examples of this last possibility are to be found in some of the recent public comments by industrial groups concerning AEC practices. I think depending alone on vocalizing by industry is a rather unsatisfactory way to bring the industrial capability of the country into closer association with Commission activities. I feel that well-defined programs of industrial liaison should be established within the AEC with the specific objective of continually presenting to industrial leadership the nature of the problems and the state of the art as viewed by the Commission laboratories. This process does take place currently, but it is not widespread nor is it widely recognized in the industrial world so that, to a very large extent, industrialists, I think, view the Commission and its work as a world apart. It will take a considerable and well organized, as well as well publicized, effort to break down the barriers between the Commission laboratories and industry. Such barriers certainly exist also between universities and industrial groups, but I do not think that they are as severe nor are the universities organized in such a way that the problem could be attacked on a broad front. Individual university efforts have been and must continue to be relied upon.

The importance of active outside participation in the research programs of the AEC becomes even greater when nonweapons work and/or nonnuclear work is contemplated in order to maintain the strength of the laboratories. I do not doubt the wisdom of retaining the weapon laboratories through the foreseeable future since they represent an enormous national military asset. If other considerations dictate that weapon research should be suspended, then effort should certainly be made to keep the weapons teams together. I fear this will be difficult to do unless one accepts the thesis that still greater feelings of com-

petition between the AEC laboratories themselves can be healthy. I confess that there are times when I feel the somewhat overlapping aims and competitive attitudes of the various AEC laboratories go beyond that which is desirable in the name of speeding scientific progress.

One particular example of contemplated nonnuclear and nonweapons work that I think deserves particular attention is the Lawrence Radiation Laboratory proposal to establish a major inorganic materials research program in which some 600 men may ultimately be required (vol. I, p. 18; vol. II, p. 73). Inorganic materials research is an extremely important and very active field and promises to remain such. While elaborate equipment for such research is required in some cases, one does not generally encounter situations comparable to those found in high energy physics or reactor and weapons physics wherein multimillion dollar facilities are the rule. The justification for a 600-man team centralized at one place to do inorganic materials research, therefore, becomes rather difficult. I do not believe that a 600-man group is really one team. I think the country's materials research program might be well handled with a number of smaller teams distributed throughout the country, but with broad coordination such as could be exercised through the research funding function of the Commission. The only justification that I, personally, can find for a very large materials program centered at one laboratory is the possibility that a more effective effort could be put forward to reduce the time required for dissemination and assimilation of results. If this were the aim of the materials program, and it is not so stated, then a large and centralized program might be very much worth attempting.

To summarize, it appears to me that there are three basic reasons for the existence of the national laboratories:

(1) To undertake large-scale developmental programs associated with weapons research;

(2) To provide and properly utilize very large experimental facilities beyond the capability of other research organizations;

(3) To serve, in an organized manner, to reduce the time required for assimilation of research results by the industrial complex of the United States.

The ability to discharge their responsibilities for weapon development must be retained even through a temporary suspension of nuclear weapons testing. In the permanent absence of a weapons program, I feel the last listed reason becomes a very weighty argument for their existence. The national laboratories have the obligation to retain their ability to produce scientific results but, more broadly, they could and should undertake the obligation to enhance the overall industrial potential of the country as rapidly as possible. They come by this latter obligation simply because they are organized and centrally directed and, therefore, could be so effective.

Sincerely yours,

L. REIFFEL,
Director of Physics Research.

ATOMICS INTERNATIONAL,
April 27, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Capitol Building, Washington, D.C.

DEAR MR. RAMEY: I appreciate the opportunity to review the AEC report on "The Future Role of the Atomic Energy Commission Laboratories". It appears to be a very comprehensive and impartial study, and the Commission is to be commended for a fine job.

In the following paragraphs I have attempted to direct my specific comments on the report to those particular areas requested in your letter of March 15.

1. *Future role of Commission laboratories by class.*—Multiprogram laboratories: I am in full agreement with the statement on page 7 describing as a basic mission of this category of laboratory the advancement of the frontiers of knowledge through strong programs in basic research and development. In numbered paragraph 3 on page 7, describing additional responsibilities for these laboratories, the statement is made that it is appropriate for investigations and developments to be carried through the demonstration of technical feasibility and far enough to judge probable economic worth of a concept. It is here that I believe judgment on an individual technical case basis should prevail, since

there well could be situations wherein industry possesses not only the capability but also a distinct advantage in performing this work. One of the largest influences on economics in nuclear powerplants can result from the philosophy of design based on the experience of powerplant operators and constructors. This design approach is most apt to be incorporated in nuclear plants if the work is done by an industrially oriented group.

2. *Policy on Commission cooperation with industry.*—The statements on pages 9–12 concerning the policy on laboratory, university, and industry relationships are most encouraging. Implementation of the policies outlined through intelligent long range technical and budgetary planning will do much to insure the most efficient utilization of the Nation's technical strength available in both Commission laboratories and private industry.

3. and 4. *R & D objectives of the Commission (sec. 2) and estimate of work level and effort on programs (pp. 13–63).*—This material is in general a repeat of information outlined in various other Commission documents such as the 10-year civilian reactor program, the annual report, and 202 hearing testimony. I have no further comment on these program objectives and work levels beyond those I presented during my 202 testimony and in subsequent letters to you.

5 and 6. No comment.

7. *Summary and conclusions (pp. 65–69).*—I was pleased to read the policy statements summarized here indicating that "increased responsibility will continue to be placed on industrial organizations to perform Commission supported development" (p. 65). The statements contained on page 67 regarding plans for Commission facilities in the event that weapons and production work are cut back are also most reassuring; i.e. "* * * there is no intention to assign them tasks that can more appropriately be performed in private facilities * * *."

8. *Plans for individual laboratories in the next decade. (Pt. II, pp. 71–165).*—(*a*) Specific plans for each laboratory appear to fit the desirable policy pattern of concentrating basic science and pioneering technology in the national laboratories with engineering development and reduction to practice carried out by industry.

I noted occasional phrases in portions of the sections on specific laboratories which might be interpreted by some as possible major deviations from this approach. As a matter of interest, I will list them. However, I feel that an intelligent technical and economic evaluation by the AEC of these future plans as they become more specific can avoid gross deviations from the policy stated above, which in the long run can only weaken our national economic and technical strength in the nuclear energy field.

Page 82: ANL—It is mentioned that work will be expanded in some fields of general reactor technology to supply information needed in connection with investigation of new reactor concepts. Areas mentioned include studies on heat transfer and fluid dynamics of liquid metal coolants, and instrumentation at very high temperatures. These areas appear to be fields in which industry may well possess facilities, personnel, and experience to conduct the work. The AEC should consider the use of private industry for this effort.

Page 91: BNL—The statement is made that significant increases are expected in reactor components programs at BNL. Even though it is mentioned that this would emphasize advanced reactor concepts, it is somewhat surprising to note a planned increase in components work by this laboratory.

Page 98: ORNL—Here again (in the area of reactor components development in which industry does possess considerable capability) it is of some concern to note the statement that at ORNL: "Minor changes in emphasis will occur within the overall program, with the largest increase in the reactor components development program."

Page 121: LRL—In reference to nonweapons work at weapons laboratories, the statement is made that: "If the Pluto concept is proved feasible, it is also likely that the laboratory will shift its emphasis somewhat from the military to broader civilian applications. The laboratory might, in this case, construct and operate small experimental reactors to pursue feasibility of such systems further." I believe that the area of civilian application of high temperature reactors, when proven feasible, is one in which the private nuclear industry should participate.

(*b*) The question as to whether the present number of scientists and the levels of effort result in the most efficient operation and productivity at the Commission laboratories is, I believe, one that can best be answered by others more closely familiar with the daily operation. The quality of decentralized leadership is the determining factor in this problem.

(*c*) I believe that greater emphasis should be given to more advanced nuclear projects. We have seen the situation in the past where the national laboratories have desired to expand their efforts in these frontier areas but budgetary support has not been forthcoming, although there was funding available for the development of operational hardware.

(*d*) It appears logical that work in fields of nonnuclear research be performed at Commission laboratories. A case-by-case evaluation of this work is necessary, however, to insure that the existing capabilities of universities and other Government laboratories are not overlooked in the placement of such effort.

In commenting on future staff requirements in volume II of this report, a varying degree of detail was used by the individual laboratories. Those who were most specific mentioned growth in staff that would essentially double their size in the next 10 years. If this trend were general among the 20 laboratories discussed in this report, their expenditures could grow from the current rate of $600 mililon per year to a rate in excess of $1 billion in 1964. The implications of this for the national atomic energy program are worthy of attention by the Committee.

In view of the AEC's policy to utilize industry for engineering development, it is of interest that volume II indicates two additional national laboratories are considering going into power reactor development. While the AEC in its introductory explanatory note mentioned specifically that it does not concur with the individual plans in some cases, there is also no specific indication that these additional expansions will not occur.

In summary, it is my opinion that the planned future role of the Commission laboratories, as outlined in the general policy portions of this report, is such that the valuable national asset they represent will continue to properly play a significant part in our atomic energy work. Concurrently, through proper budgetary and technical planning, private industry with its growing capability should be an essential and growing part of the Government's atomic energy program.

Sincerely yours,

C. STARR,
President, Atomics International Division.

BATTELLE MEMORIAL INSTITUTE,
May 16, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I have studied in detail the two volumes of the report on "The Future Role of the Atomic Energy Commission Laboratories." The report is certainly very well prepared, and I find it impossible to take any issue with the conclusions. The role of the Commission laboratories is certainly an essential one. Their work has been done well, and it seems to me that the plans made for the next 10 years must be carried on in the way recommended for the simple reason that there is no alternative way that will guarantee that the work will be done.

Sincerely yours,

B. D. THOMAS, *President.*

BECHTEL CORP.,
San Francisco, Calif., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy Engery, Congress of the United States, The Capitol, Washington, D.C.

DEAR MR. RAMEY: We appreciate the opportunity afforded us to comment on the AEC report, "The Future Role of the Atomic Energy Commission Laboratories," which you forwarded to us on March 15, 1960.

We are not ourselves engaged in research and development as such but are very much interested in the future role of the AEC laboratories in the field of nuclear power where we plan to continue our present role as engineers and constructors for all types of nuclear power facilities.

While the AEC report is an excellent description of the facilities and technical resources of the various laboratories, the programs which they have carried out and are engaged in, and of the programs and facilities planned it does not, in

our opinion, adequately cover the philosophical basis needed for the establishment of long-range policies. The report appears to justify, preserve, and somewhat enlarge upon the "status quo."

The AEC laboratories represent a great national asset in scientific and engineering talent, in large-scale capabilities, and in unique facilities. Effective utilization of this national resource is of extreme importance in this era of increasingly advanced technologies. It is our belief that these laboratories will ultimately find many of their challenges and successes in research fields outside their present scope and that of the AEC. Serious thought should be given to gradually broadening their scope to areas of technological development outside the atomic energy program.

In the area of civilian power reeactor development we believe that the AEC laboratories should play a continuing and important role. However, we do not believe that this should be in the field of industrial development of reactors. It is necessary to repeat a statement which has often been made before—that the reactors which will be utilized commercially are going to be manufactured and built by private industrial companies, not by the AEC laboratories.

These industrial companies must have direct experience with the component development work, with many aspects of the research, and with the design and construction of prototype reactors if they are to be able to offer high performance and reliable equipment and services at an economic price. They cannot obtain the direct experience they must have from reading reports or even from acquiring experienced personnel from the AEC laboratories. Thus, it would appear that the least costly and most effective manner of achieving commercially useful nuclear power would be to rely to the maximum practicable extent on the industrial developers and manufacturers rather than the AEC laboratories.

On the other hand, there is a vast amount of basic scientific and engineering data which is necessary for the development and design of both present and future types of reactors and which the AEC laboratories are uniquely qualified to obtain. This includes many aspects of physics, materials, fluid mechanics, and heat transfer, etc. It also appears appropriate for the AEC laboratories to experiment with new ideas for reactors, unique ideas for improving older types, and new idea in related fields such as chemical processing, and certainly improvements in basic fuel element technology.

The development of long-range types of reactors such as breeders is also an important area where the AEC laboratories should play an essential role in reactor development. These types should be developed so that there will be a sound technological basis for their use by industry at such time as economic forces change to make their use desirable.

We have endeavored to prepare comments where appropriate on the specific points raised in the attachment to your letter. These follow according to the numbering of your attachment.

1. Item 3 on page 7 (multiprogram laboratories) crystallizes some of the thoughts discussed above. The question is as to how far the laboratories should go in demonstrating technical feasibility and probable economic worth of a concept. It must be kept in mind that these demonstrations are only effective if they convince industry which will build and use the reactors (or other concepts). The judgment is likely to be much more realistic and profitable if the engineering development phases are prosecuted by those who must evaluate the results in terms of their own future investments.

2. While these policies go in the right direction, subject to the above comments, the implementation of them needs to be strengthened. Some positive means should be found to insure that industry is given every opportunity to strengthen its experience and capabilities.

3. On page 17, item (*a*) (civilian reactors) we would suggest that the objective be restated as "Assist U.S. industry to reduce the costs of * * *." These costs will depend on what industry can do with the experience and data it has available.

4. This section presents a budgetary program for the orderly expansion of the present programs based on present policies and philosophies. The validity of such projections is dependent on the broader issues not discussed in the report.

5. This is directly related to the other comments.

6. No comment.

7. "We believe that this is desirable if the laboratories are to continue as a strong national asset. However, in expanding the nonweapons work we be-

lieve serious consideration should be given to selecting new research fields of major long-range importance. Transfer to short-range work (such as engineering development of power reactors) is not likely to provide the long-term stability desired.

8. (*a*) Laboratories pursuing reactor development programs of types that have reached the industrial prototype stage should work in support of the industrial prototypes rather than in competition with them. Engineering development work should be transferred, where possible, to industrial contractors with unique facilities and services made available to the contractor's program. Such policies do not appear to be adequately reflected in the proposed programs.

(*b*) It is difficult to generalize with respect to the size of laboratories for this depends to a large extent on the type of work and on the organization and leadership. In general, a larger number of smaller laboratories will probably be more effective. Some of the AEC laboratories appear to be near, if not in some cases beyond, their optimum size.

(*c*) This is certainly in agreement with our thinking. However, care must be exercised inasmuch as mere novelty does not necessarily make a project worth doing even though it may be done well.

(*d*) As we have indicated above, we feel that ultimately the AEC laboratories will find great additional usefulness in research fields other than the purely nuclear.

We would like to conclude with the thought that the objectives and policies once established must be implemented with the wholehearted support of all concerned. Effective means must be established to assure this as well as to review and evaluate progress, and, if need be, to reestablish the objectives and policies. The Joint Committee can, of course, serve as a powerful force in this process.

Very truly yours,

J. P. YATES,
Executive Vice President.

BURNS & ROE, INC.,
New York, N.Y., April 12, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: This will acknowledge your letter of March 15, 1960, in which you asked for comments on the future role of AEC laboratories and the Commission's report on the same subject. The writer personally is not sufficiently familiar with these laboratories to give you any worthwhile suggestions. Therefore, the suggestions contained herein are the suggestions of our staff who are more familiar with the laboratories and their problems. We would comment as follows:

1. *The future role of Commission laboratories.*—One important activity of the so-called multipurpose laboratories (such as Argonne, Oak Ridge, and Brookhaven) should be the training of foreign scientists. This particular item was not discussed, but we believe it is most important in connection with the need for helping underdeveloped countries improve their technical capabilities. The AEC should be encouraged to expand its programs in this category by accepting foreign students to work at these well-equipped facilities so that in time they can go back to their own countries and establish good technical organizations. Another advantage of these multipurpose laboratories would be the lending of U.S. scientists to foreign countries to assist them in establishing their nuclear installations and in training their personnel.

This, of course, should be on the basis of helping the countries which form a long-range viewpoint will be helpful to us and not countries which might be harmful to us.

The project engineering laboratories referred to—which include the ANP work at Evendale and CANEL, the naval propulsion work at Bettis and Knolls and the weapons development at Sandia—appear to have a certain overlap with the multipurpose laboratories' activities. The project engineering laboratories do include to a certain extent basic research whereas, on the other hand, the multipurpose laboratories have been going into hardware development. We would recommend that this overlap be reduced so that the basic research would still be in the hands of the multipurpose laboratories and the development and hardware production activities carried out by the project engineering laboratories.

Production plant laboratories (Hanford and Savannah River) have very high power reactors which should be utilized in a number of other activities should there be a reduction in the need for plutonium. Should convertibility be possible, it would be sensible to convert as many of these reactors as possible to power producers so that they may be kept in operation should the production requirements be appreciably reduced. Also, since these are high-power reactors they could be utilized as a source of isotope production as well as in-pile testing facilities.

The university laboratories (Argonne Cancer Research Hospital, Cambridge electron accelerator, Princeton-Pennsylvania proton accelerator, stellerator, and the University of Rochester biomedical project) are valuable assets to the nuclear program provided they are competently staffed.

2. *Policies for Commission cooperation with universities and industry.*—In the recent past, there has been a great deal of pressure on the part of universities to assume the nuclear training that has been done for some time by the multipurpose laboratories. No one can argue with this approach. The basic teaching of nuclear science does belong in the university. However, this has not always been successful because the universities have been inadequately staffed with trained personnel as well as inadequate equipment for research. For this reason, teaching has not been as satisfactory to nuclear students at universities as at the laboratories. Therefore, a great deal more development must still be carried out by the universities to bring themselves to a level of competency equal to the laboratories before they can assume their full teaching responsibilities. Again the universities would make an excellent training ground for foreign students.

There has been appreciable pressure in recent years, particularly through the Atomic Industrial Forum, to give industry more basic research and development contracts rather than to do this work at the AEC laboratories. This practice would be all right if industry can demonstrate competency equal to the laboratories. Undoubtedly there is a gray area between what is considered basic research and what is developmental hardware for production. Where a development of hardware for production is indicated, then industry is the logical choice for such R. & D. contracts.

3. 4, and 5. These items give a fairly good evaluation of the future role of the Commission laboratories, facilities and level of effort.

6. *Plans to continue support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories.*—This plan would be good provided, as commented above, the universities are properly equipped to carry out this basic research. Unfortunately, the best equipment is still at the AEC laboratories and the degree of research is only as good as the available research tools. It might be a great deal better to have the universities do their research at the Commission laboratories, such as Brookhaven, rather than to duplicate this costly equipment at the universities.

7. *The Commission's intent to consider maintaining the strength of the weapon laboratories by expanding nonweapons work at such laboratories if necessary.*—It probably will be better for security and also to promote the private enterprise system for the weapon laboratories to be confined largely to weapons work rather than to compete in the nonweapons field with already established private facilities. If there were any substantial volume of noncompetitive, nonweapons work which could not be handled by the private laboratories—which we doubt to be the case—then some of that work might possibly be done in the weapon laboratories to maintain manpower. But even then it would increase the security problems which might prove undesirable.

8. (*a*) and (*b*). It appears to us that there is a certain amount of duplication in research programs at many of the laboratories. For example, high-energy particle accelerators are at Argonne, Brookhaven, Oak Ridge, and Livermore. There are similar multiplicity activities in the biological research field and there are at least four or five laboratories active in control thermonuclear fusion. By diversifying these research programs to the degree of four or five different laboratories, it would appear that not only is there duplication but also dilution of the available talent. A certain amount of competition among laboratories is healthy and it should be encouraged among possibly two and maybe three installations. However, when this is created among four and five, then we think we have passed the point of maximum return.

8. (*c*) and (*d*). The plan to put greater emphasis on nuclear research and development is good. We believe that nonnuclear research should only be done in the laboratories where it is a contingent necessity for advanced nuclear re-

search. The laboratories have the best equipment and top scientists and, therefore, are naturals for doing advanced research in nuclear and affiliated activities.

The AEC report is very comprehensive and does a fine job of defining the cost, personnel, and planning for the future. We hope our comments will be of value to you.

Very truly yours,

RALPH C. ROE, *President.*

CALIFORNIA RESEARCH CORP.,
San Francisco, Calif., April 28, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Your March 15 letter to Dr. D. E. Hull of our Richmond Laboratory requested comments on the AEC reports on the future role of the AEC laboratories.

We support the Atomic Industrial Forum's position as expressed in their recent report "Atomic Research and Development—The Role of Industry."

We are not at all certain that the 10-year plans for growth and program of AEC laboratories adequately consider the role of industrial participation. Effecting and maintaining the proper balance between AEC laboratory programs and industrial research capability is one of the major problems facing the AEC and the atomic industry.

We appreciate the opportunity to read and comment upon the AEC report you sent to us.

Very truly yours,

A. L. LYMAN, *President.*

COMMONWEALTH EDISON CO.,
Chicago, Ill., April 26, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Washington, D.C.

DEAR MR. RAMEY: Responsive to your request which came in while I was away, I am sending you the comments of my people on the reports pertaining to the future role of AEC laboratories.

Murray Joslin gave you a report on how we are getting along at Dresden. Needless to say, we are very well pleased and hope we will be permitted to proceed to full power operation after the coming hearing.

We were glad to hear that a general provision has been made in the authorization bill for fiscal 1961 covering further work on a reactor of the graphite boiling and superheating type. As I said before, the concept is attractive but we and our NPG partners have substantial commitments and had to pass it up.

Best personal regards.

Sincerely,

WILLIS GALE, *Chairman.*

COMMONWEALTH EDISON CO. COMMENTS ON THE FUTURE ROLE OF AEC LABORATORIES IN THE CIVILIAN POWER REACTOR PROGRAM

We have carefully reviewed volume I: "Analysis and Conclusions" and volume II: "Supplemental Materials," both on the subject: "The Future Role of the Atomic Energy Commission Laboratories." Specific comments will be directed to the power-reactor aspects of the national laboratories work because this is the field with which we are most familiar. However, we are impressed with the objectivity and thoroughness of this reexamination and reappraisal of the work of institutions which have done so much for our country's welfare. In this vein we acknowledge our indebtedness to Argonne National Laboratory with which we have worked so closely since early in 1951 when we first began our studies of nuclear power.

Our specific comments are as follows:

Volume I, page 35—"Light Water Cooled Reactors" and Volume II, pages 20 and 21, reference to boiling water reactors.—We question the need for AEC to build prototypes for advanced design reactors of either the pressurized or boiling water types inasmuch as manufacturers are offering large-scale plants on a fixed-price basis with a fuel-cost guarantee. On the other hand, the laboratories

using design information and operating exeperience from existing reactors and from those now under construction, could address themselves to small-scale component development which would be less costly and more likely to pay off.

Admittedly the development of nuclear superheat needs to be pushed. However, it might be less costly to use existing experimental or prototype reactors for research and development in this field instead of building new reactors.

We agree that the laboratories are well equipped and have the talent to conduct research aimed at reducing fuel costs along the several lines mentioned. This is of prime importance to the future of economic nuclear power.

Our observations at Dresden to date and our joint study on reprocessing with Davison Chemical Division of W. R. Grace Co. lead us to point out two possible fields in which the laboratories can be helpful:

1. Development of more dependable in-core instrumentation: We believe that precise and dependable knowledge of just what is going on throughout the core of a large power reactor will enable the operators to achieve longer burnup with consequent reduction in fuel cost.

2. Improve the accuracy of assaying nuclear materials after reprocessing: Present information about existing reprocessing methods indicates that accuracy in assaying analysis of nuclear fuel can be expected to be off as much as 10 percent with the first reprocessed batch and about 2 percent after techniques are improved and more experience is gained. Such inaccuracies involve large sums of money and may deter some from entering the field of nuclear power.

CONSOLIDATED EDISON CO. OF NEW YORK, INC.,
New York, N.Y., April 22, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR MR. RAMEY: Although my company is not in the business of competing for nuclear research and development work, the subject is one which is so closely related to the long-range development and utilization of atomic energy that I am happy to respond to your invitation of March 15 to comment on the future role of the AEC laboratories.

It is most natural for individuals with initiative and competence, who have taken an idea and by their knowledge and work advanced it a stage approaching feasibility or even commercial realization, to want to see it through. Their natural and even laudable inclinations, however, should not necessarily be a determining factor in policy decisions of the Atomic Energy Commission.

If the AEC's laboratories are to be most productive and contribute most effectively to atomic research and development, they must be continually giving up projects somewhere short of proven commercial feasibility. They must do this for two reasons. It is important that they concentrate on frontier or early-idea activities for which they are uniquely qualified, and to do this they must always be giving up work at one end so they can concentrate on the beginnings. And they must give up their projects at some stage of progress so that industry can be encouraged to assume more of the burden of atomic development.

Industry must gain experience and know-how at an early stage of engineering development if it is to make its greatest contribution, not only in terms of accomplishment but also in terms of employing more of its own money, and less of the Government's, in advancing and improving nuclear technology.

I am sure that there are many instances where AEC laboratories have relinquished projects at some stage short of commercial proof. But, human nature being what it is, I am also sure that there are other instances where AEC laboratories have carried projects well beyond the stage of potential industrial application.

I believe that there is a situation here which requires increased attention. Among other things a more effective procedure must be found to evaluate on a continuing basis the progress which is being made in building up a healthy atomic industry at the same time the AEC laboratories pursue research work on the frontiers of science. I believe that the recommendations included in the paper prepared by the staff of the Atomic Industrial Forum, in which it is proposed that the AEC appoint an ad hoc committee to discuss and perhaps come up with

a better definition of the respective roles of industry, the universities, and the AEC-owned R. & D. laboratories, would help to put this matter into proper perspective.

Some better system also should be found to enable industry to make known its ideas and proposals to the AEC on a regular basis comparable to the annual budget submissions of the AEC laboratories. Such a system is necessary if industrial talents are to be brought to bear most effectively in performance of AEC-sponsored R. & D. projects.

The Atomic Energy Commission and the Joint Committee are performing a useful service by considering the R. & D. question. Because this is an area where the dynamic quality of both Government- and industry-financed research must be preserved, it is most important that Government, industry, and public attention be given to it.

Sincerely yours,

J. F. FAIRMAN,
Senior Vice President.

CONSUMERS PUBLIC POWER DISTRICT,
Columbus, Nebr., April 15, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We appreciate your invitation to comment on the future role of the Atomic Energy Commission Laboratories. As an operating electric utility participating in the power reactor demonstration program, our organization is keenly aware of the necessity of maintaining an effective scientific program in the national laboratories as well as in non-Federal organizations participating in the atomic energy industry. The existence of a versatile staff of scientific personnel operating in completely integrated laboratories is undoubtedly one of this country's most valuable assets. (In order to maintain the laboratories' effectiveness in an expanding national economy which is experiencing an increasing dependence upon the various scientific disciplines, the Commission should set as an objective, a corresponding expansion of laboratory facilities and competent personnel.)

In attaining this objective the Commission must continue to support universities' basic research programs. The maximum utilization of the personnel and facilities of these educational institutions will permit a continued growth of basic information and trained personnel required by the laboratories for the prosecution of their larger integrated programs. In addition, those laboratories currently concerned with weapons development should be encouraged to enter nonweapons activities if required to maintain and expand their capabilities as a dedicated scientific task force.

Private laboratories, as the third elements of our scientific community, must not suffer as a result of the university and Federal laboratories. Regardless of the general guidelines established, the balance of support for these three elements of scientific research will be difficult to maintain.

We are of the opinion that the AEC laboratories should provide a transition between the basic science research carried on in individual disciplines by the universities and the commercial engineering applications by industry. This middle ground of developing "first of its kind" systems whether in the space programs, weapons programs, or peacetime applications of atomic energy, should provide adequate freedom to maintain the interest of laboratory personnel and should provide for the dissemination of technical information to the universities and industry.

The above comments represent the thinking of those of consumers district's organization directly concerned with this matter.

Very truly yours,

R. L. SCHACHT, *General Manager.*

THE DENVER & RIO GRANDE WESTERN RAILROAD CO.,
Denver, Colo., April 13, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Congress of the United States, Joint Committee on Atomic Energy, Washington, D.C.

DEAR MR. RAMEY: I appreciate receiving your letter of March 15 and attachments. My comments regarding the future role of the AEC laboratories are as follows:

The program for the next 10 years technically, as proposed, is quite extensive in scope. However, the most striking feature in the program is the apparent lack of concern with the development of any land transportation type of reactor. There are definite programs for marine use, air use, large scale power generation, process heating, and small stationary powerplants. All of these projects will eventually benefit a segment of the industry of this country and will eventually lead to new products and applications. None of these programs appears to be suited for development into aiding the land transportation industry of this country. It is apparent from the report that any of these programs can only be financed by governmental, and specifically AEC, aid.

The statement on page 10, vol. 1, clearly indicates the intention of the Commission to develop projects and move them on to industry application and utilization. Page 11 outlines the means of doing this type of work. We have already undertaken suggested item 1. We are now ready for a Commission contract under item 2. Perhaps the soundest way of proceeding is to take advantage of the proposal in item 3 and place a man in the lab that is working most closely with a project applicable to our needs.

Under the "Objectives of the maritime reactors" are set forth two basic objectives that should be the guide for land transportation development: development of a light weight compact nuclear plant that can successfully compete with conventional power and, secondly, to develop operating and maintenance practices for such a plant. Perhaps the most important subsidiary objective, and one that has been largely ignored or even commented on adversely by published statement of the Commission's personnel, is contained in item 2, page 15, in which the Commission states it should "cooperate * * * and furnish technical assistance in securing acceptance of nuclear merchant ships in unrestricted domestic * * * commerce." This objective, when applied to land transportation has certainly not been met and has in fact been argued against by very highly respected members of the Commission's laboratories.

There appears to be a possibility of including land transportation reactors somewhere under "Special purpose reactors," perhaps under "Naval or military powerplants." It would seem that under either of these two classifications a 5,000 kilowatt electric plant would eventually be needed. Another possibility is under "Civilian reactors," item d, "Maintain the United States' position of leadership in the technology of nuclear power for civilian use." It is recommended that a suitable subsection be formed under the appropriate broad classification of either "Special purpose" or "Civilian reactors" whose function will be to foster the development of a light-weight, compact suitable reactor of approximately 5,000-kilowatt electric capacity for use as small land unit or possible power application on railroads. It is further recommended that someone from the railroad industry be included in this subsection to provide the specialized knowledge of the industry that will be required. It is further recommended that a suitably qualified man from the railroad industry be assigned on a temporary basis to a Commission laboratory that is working on reactors that appear to hold promise for the industry.

Thank you very much for the opportunity offered me to send in these comments.

Sincerely,

RAY MCBRIAN,
Director of Research.

EBASCO SERVICES, INC.,
New York, N.Y., May 26, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Congressional Committee on Atomic Energy, Washington, D.C.

DEAR MR. RAMEY: This is in response to your letter of March 15, 1960, to Mr. F. C. Gardner requesting comments on volumes I and II of the report "The Future Role of the Atomic Energy Commission Laboratories."

The report is a carefully prepared analysis of national laboratory programs, costs and manpower. It should provide a sound basis for the evaluation of AEC laboratory functions and for the planning of their role in the further development and use of atomic energy.

In general, we are in agreement that in the fields of basic research and weapons development the role of the AEC laboratories should be continued and perhaps expanded. For basic research in the nuclear field, unique and expensive equipment and facilities are required which can appropriately be made available to educational institutions and industry through the mechanism of national laboratories. Furthermore, because of the high cost of modern research in this field, it appears wise as a matter of national security to supplement the research staffs of educational institutions and industry by having a separate and additional group of qualified scientists perform basic research in AEC laboratories. For weapons development, the distinguished record of the AEC laboratories is in itself justification for continued and expanded performance of such work as a matter of sound defense policy.

However, in the field of applied research for the development of commercial power reactors, we believe that the role of the AEC laboratories should be contracted, not expanded. Such a contraction of effort in power reactors would make available additional manpower and facilities within the national laboratories for application to basic research and weapons development, thereby making largely unnecessary an expansion of the laboratories.

Our comments are set forth below in terms of the AEC's grouping of national laboratories:

University laboratories.—The Argonne Cancer Research Hospital, Cambridge, electron accelerator, Princeton-Pennsylvania proton accelerator, Princeton stellarator, and University of Rochester biomedical project activities should be expanded. Their functions are primarily basic research. An economy with the gross national production of the United States can justify additional expenditures aimed at increasing our fundamental scientific knowledge.

Production plant laboratories.—Hanford and Savannah River Laboratories comprise primarily a means of improving the processes and products of plants for the production of fissionable materials for national defense purposes. Whatever expansion is required by defense production needs is justified by those needs. At the same time, every effort should be made to assure that such expanded needs are met to the fullest extent possible by industry operating in a normal commercial manner rather than by expansion of the Hanford or Savannah River facilities. Moreover, these laboratories should not generally be given additional assignments outside of production process improvement. Such assignments should be made on a contract basis to manufacturing, engineering, or development organizations.

Project engineering laboratories.—Sandia, KAPL, Bettis, and ANP Laboratories at Evendale and in Connecticut are engaged primarily in the development of military reactors, components, and systems. Their work should be expanded as military requirements justify expansion. However, every effort should be made to utilize manufacturing, engineering, and development organizations on a subcontract basis.

Multiprogram laboratories.—The functions performed by Argonne, Brookhaven, Oak Ridge, Ames, Los Alamos, and the Lawrence Radiation Laboratories are broad and varied. Their basic research in the physical sciences and biological and medical research should be continued and perhaps expanded. However, the major part of the project development and applied research and general development performed by them should be shifted gradually from the national laboratories to manufacturing, engineering and development organizations, thus freeing manpower and facilities for greater effort on basic research and weapons development. Industry should be given greater financial incentives to undertake applied research and development and project development work in their own facilities with their own staffs. To the extent required, the AEC should contract directly with industry for the performance of contract research and development and, as necessary, should provide Government-owned equipment and possibly

capital facilities. In any event, the work of the national laboratories in the field of applied research and development should not be permitted to compete with the efforts of industry.

We recognize that the achievements of the national laboratories have been significant. However, we believe that the reorientation suggested above, by better implementing the policy objective "* * * to strengthen free competition in private enterprise * * *" as expressed in section 1 of the Atomic Energy Act of 1954, will give greatest assurance of more and better accomplishment at least cost to the Nation.

Very truly yours,

W. H. COLQUHOUN, *Vice President.*

EVANS RESEARCH & DEVELOPMENT CORP.,
New York, N.Y., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

GENTLEMEN: Thank you for your letter of March 15 concerning the future role of the Atomic Energy Commission laboratories. We have studied the material, which was enclosed, and consider that the subjects covered in the reports well chosen, with no obvious material overlooked, and well treated. The main problem of the Commission is a close integration of its program with industry and universities, so that there is an overall development of atomic energy which will be of greatest benefit to the Nation.

We are pleased to offer comments and suggestions about the report and are addressing our remarks to specific items No. 2 and No. 3, concerned with "Policies for Commission Cooperation With Universities and Industry," and "Research and Development Objectives of the Commission Laboratories," respectively.

In addition to the program the Commission intends to support, it should also support programs in industries besides those directly concerned with atomic energy, such as food, clothing, construction which are of paramount importance in everyday living. The use of all forms of atomic energy and its byproducts as a tool should be encouraged in other industries, besides the atomic industry, because this would benefit both the general public and industry. In a rapidly developing and growing field such as this, the skills and knowledge necessary to use this tool can only be gained by other industries, if the Atomic Energy Commission and its national laboratories vigorously supports development programs in these industries. While it is fully recognized that these industries must themselves support commercialization of the tool of atomic energy, this will only occur if the Commission initiates development programs in many industries.

In order to achieve this purpose the Commission should have strong national laboratories to provide a continuous flow of experience and knowledge and to disseminate this to the public as a whole. If too much of the responsibility for basic research and development is taken out of the hands of the Commission and its national laboratories there may develop monopolistic uses of this valuable national asset by large corporations. We do not support the attempts that are being made to create a public climate favorable to decreasing the size and effort of the national laboratories and to assigning their function to the commercial atomic industry. As an independent company, we feel that these laboratories serve a very useful purpose to the smaller businesses engaged in the atomic industry and their continued existence as strong and vigorous public centers of research and development is necessary for maximum public benefit of atomic energy. While we agree that the national laboratories have an important place in the overall national research effort, these comments are directed to the value of these laboratories to small business.

The Commission can best introduce the concepts of atomic energy as a tool to the more important industries concerned with day to day living with the support of small development contracts. This should be done in a large number of industrial laboratories supplementing this support with the facilities of the national laboratories. Although some development contracts may not achieve the immediate scientific goal for which they were intended they are very useful since the industrial laboratory achieves first hand experience of this valuable industrial tool.

While it is important for the Commission to keep in mind that general training and education in the use of atomic energy as a tool can be best done by the universities, new uses in already established industries will only result when

management has a clear demonstration of its usefulness in its own industry, this is most effectively done in industry's own laboratories.

We hope that our comments and suggestions may prove of value to the Joint Committee.

Sincerely yours,

ERIC J. HEWITT, Ph. D., *Vice President.*

THE H. K. FERGUSON CO., INC.,
Cleveland, Ohio, April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
U.S. Capitol,
Washington, D.C.

DEAR MR. RAMEY: In response to your request for comments on the future role of the Atomic Energy Commission's laboratories, we have reviewed the AEC's report to the Joint Committee on its present and projected plans for the laboratories and our comments are attached.

We appreciate the opportunity to review and comment on this report.

Very truly yours,

R. W. OLMSTEAD, *President.*

COMMENTS ON THE ATOMIC ENERGY COMMISSION REPORT TO THE JOINT COMMITTEE ON ATOMIC ENERGY ON THE FUTURE ROLE OF THE ATOMIC ENERGY COMMISSION LABORATORIES

1. The future role of Commission laboratories

The indicated future use of the Commission laboratories is comprehensive, within their capabilities and consistent with their past performance.

It should be noted that as more nuclear experience is gained in industry a greater percentage of new concepts for harnessing and using nuclear energy will originate from individuals and industrial organizations. Such concepts, requiring Commission support, should be given equal consideration with concepts originating in the laboratories and the laboratories should be used to complement the efforts of industry in developing these concepts far enough to provide a basis for judging their technical feasibility and probable economic worth.

2. Policies for Commission cooperation with universities and industry

The stated policies for Commission cooperation with universities and industry are excellent. The interests of the American people are best served by such close cooperation.

3. Research and development objectives of the Commission laboratories

The outlined research and development objectives of the Commission laboratories are consistent with the objectives stated in the Atomic Energy Act. An effective research and development program aimed at accomplishing these objectives can speed the economical use of atomic energy and improve the general welfare.

It is suggested that private industry can make major contributions in certain areas of this program, particularly in the development and application of reactor systems and components to military, civilian, and auxiliary powerplants.

5. Future safety additions and replacement plans

The Commission plan for replacing temporary structures which house permanent laboratory activities and for restricting major additions to experimental plants and devices is excellent. This plan is consistent with the Commission's increasing reliances on industry and the universities as the research and development program expands.

6. Plans to continue the support of greater increases in base physics research and biomedical research at universities rather than at Commission laboratories

The plan to support greater increases in the basic physics research and biomedical research at universities rather than at Commission laboratories should bring a larger number of special talents into the program than would be possible if this work were restricted to Commission laboratories. This plan should result in earlier results and lower costs.

7. Maintaining the strength of weapon laboratories by expanding nonweapons work

The Commission's proposed intent to maintain the strength of the weapons laboratories by expanding nonweapons work at these laboratories should be carefully examined. The assignment of nonweapons work to these laboratories should be made only if such work can be performed better and more economically there than in the other Commission laboratories or in industry. A program for maintaining these laboratories at the expense of other laboratories and programs would not conform to the objectives of the national atomic energy policies nor would it be in the best interest of the American citizens.

GENERAL ATOMIC,
San Diego, Calif., April 22, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We appreciate your invitation to comment on the report prepared by the Atomic Energy Commission concerning the future role of the Atomic Energy Commission laboratories.

In general, we regard the report as a constructive study and we share the belief that the Commission should continue to support strong multiprogram atomic energy laboratories to help assure the Nation's continued leadership in the field of atomic energy applications. These laboratories serve as important research centers for the continued development of the means of protecting our Nation's security through both weapons technology and peaceful applications. We also agree wholeheartedly with those sections of the report which state that industry and universities have substantial and growing shares in atomic energy responsibilities, and that the Commission must assure that its national laboratories continue to complement the proper activities of industry and the universities, thereby encouraging and strengthening competition in private industry, and stimulating the universities in their prime role of education.

Our specific comments on those particular areas of the report referred to in the attachment to your letter of March 15 are as follows:

1. It seems to us that the description of the role of the various categories of Commission laboratories is generally well stated. We strongly endorse the statement (p. 10, vol. 1) that the Government laboratories should not be assigned exclusive areas of work for which they alone will receive Government support. However, the wording of this section of the report conveys the impression that the Government laboratories are to occupy a position of priority. For example, the report states (p. 7, vol. 1) that the Commission intends to "rely on its multiprogram laboratories" in conceiving new devices for harnessing nuclear energy and new uses to which nuclear energy may be applied. In this connection, the report speaks specifically of controlled thermonuclear reactions, direct conversion, mobile reactors, and new concepts of stationary reactors. The report further states that the national laboratories should be assigned such programs, and should pursue them to the point of establishing technical feasibility and basis for judging probable economic worth, after which there should be an "orderly progression to industry" (p. 10, vol. 1). This conclusion is susceptible to the interpretation that initial conceptual and development work in the areas listed above should be, first of all, the responsibility of the Government laboratories and that industrial laboratories should be assigned such projects only after technical feasibility is established and a basis exists for determining probable economic value. In this connection, we note that the committee's press release of March 17 summarizing the report says the Commission laboratories would "remain paramount" in pioneering new concepts. In contrast to this stated thesis, we believe that whatever the Commission can find outside of its own laboratories, either in industry or in the universities, technical competence and interest of equal or greater strength to deal with some of these problems and to produce and develop new concepts, it should be obligated to consider carrying out programs within such institutions. In the long run, we believe that encouragement of the universities and industry to acquire such technical competence—not to supplant the national laboratories but to supplement them—will be in the best interest of the Nation. Furthermore, such encouragement is essential in strengthening free competition in private enterprise, an objective of the Atomic Energy Act.

2. The general statement of policies for Commission cooperation with universities and industry, in our opinion, should be supplemented by expansion of

the description of the role of industry. The description contained in the report (pp. 10–11, vol. 1) appears to be too restrictive. For example, it does not include direct contracts between the Commission and private industrial organizations for research and development activities, a most important relationship in the development of strong American industry. Also, the examples of types of Commission contracts with industry for component development, nuclear control devices, conceptual design study, etc., are far too restrictive. In brief, we would suggest that where appropriate technical competence exists, private industry be asked if it desires to undertake Commission work on contract basis in any area.

3. While we do not disagree with the research and development objectives of national laboratories, as contained in pages 13 through 26 of the report, our observation is that since these are indeed vital Commission objectives, the combined roles of universities and industry along with that of the national laboratories should be recognized as the most vigorous total approach to the attainment of such objectives.

4. The section of the report dealing with estimates of the changes in work and level of effort described on pages 27 through 63 appears to represent a reasonable forecast of the Commission programs and a reasonable description of effort. It is apparent from other parts of the report that the increased effort in the various fields identified will go exclusively to national laboratories. It is not clear whether or not similar increased effort would be earmarked for work in universities and industrial laboratories. While it seems logical to us that fairly substantial increases in effort be made in a number of these fields, it seems, from a practical standpoint, that the relative role of industrial laboratories in the Nation's atomic energy program could only become one of decreasing importance if all or a substantial part of the increases contained in the report are, indeed, directed solely to national laboratories. It is quite possible that we have misread the intent of the report in this regard.

6. As to the questions concerning biomedical research at universities, we believe in the statement of the Commission policy as it is reviewed in the report.

7. It seems to us that it is highly essential that the strength of the weapons laboratories be maintained and that work at such locations should be logically expanded into the nonweapons area. We think also that such expansion should contemplate work in fields not directly related to nuclear energy as well as nonweapons nuclear work.

8. It is not possible for us to comment intelligently on the possible changes in staff and program emphasis at each of the laboratories. However, it is our firm belief that the achievement of future successful applications of nuclear power will be made possible only with the acquisition and application of more basic information than we now have available in all fields of science. We feel strongly that emphasis placed on the acquisition of information on the behavior of materials at high temperatures and a better understanding of basic physics will be of increasing importance. Attention to these subjects in the national laboratories in balance with their advancement, chiefly in universities and with equitable emphasis in responsive industry, is a necessary condition for the vigorous development of the total technology.

Very truly yours,

FREDERIC DE HOFFMANN,
Senior Vice President, General Dynamic Corp., and
President, General Atomic Division.

KAISER ENGINEERS,
Oakland, Calif., April 29, 1960.

JOINT COMMITTEE ON ATOMIC ENERGY,
Congress of the United States,
Washington, D.C.
(Attention: Mr. James T. Ramey, Executive Director.)

GENTLEMEN: In response to your letter of March 15, 1960, the following comments on the Atomic Energy Commission's report "The Future Role of the Atomic Energy Commission Laboratories" are respectfully submitted. These comments are presented in the order of the specific items set forth in the attachment to your letter.

1. The future role of Commission laboratories by class

In order to minimize the expansion of the multiprogram laboratories, which would result from assignment of "new projects," and at the same time to study

the programs of the project engineering and production plant laboratories, it would seem that certain projects involving "new devices for harnessing nuclear energy" (for example, mobile reactors) might be assigned to some of the project engineering laboratories whose experience and current facilities relate to mobile and other special nuclear applications. The assignment of such projects to the project engineering and production plant laboratories should be done not for the purpose of expanding those laboratories at the expense of the multipurpose laboratories but, rather, as a means of maintaining continuity of workload and stability over the entire AEC laboratory setup.

2. Policies for Commission cooperation with universities and industry

We are in agreement with the policies described for the Commission's cooperation with universities and industry, and very earnestly hope that the AEC is able to enforce these policies. Certainly it is going to take continuous review and courageous enforcement to insure that the Government laboratories do not compete with private industry. We believe that a deviation from the policies described will certainly create an environment that will impede the normal industrial growth in the development and commercial applications of nuclear energy.

3. Research and development objectives of the Commission laboratories

In general, the described objectives of each of the AEC laboratories seem reasonable.

4. Estimates of changes in work and level of effort in Commission research and development programs

We note that with few exceptions, all of the laboratories contemplate growth in the next decade. (Growth itself should not become an objective. Increases in staff and facilities at AEC laboratories should occur only when, in full compliance with the Commission's policies on private and other non-Government research and development, such increases are unavoidable.

5. Future facility addition and replacement plans at Commission laboratories

As mentioned in No. 4, above, well-considered expansions of the Government laboratories to insure the high quality of work done at the laboratories may be necessary. We believe that the AEC should also be concerned with, and should encourage the expansion of, industrial nuclear research and development facilities.

6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories

The plans seem to us to be very proper.

7. Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary

We assume here that the Commission's intent is based on the necessity of maintaining the strength of our "weapons laboratories" in the interests of ready mobilization of our military efforts in the event of war. It is difficult to comment on this in generalities, but it certainly is an area which should be approached very cautiously by the AEC since it implies the diversion of research work which otherwise would be done somewhere else, to one of the AEC laboratories in order to make work for that laboratory. We do not doubt that this at times will make sense, but each instance should be considered in the light of its impact on the institutional or industrial research facilities which otherwise would have been called upon to do the work involved.

8. (a) Planned changes in staff and program emphasis at each of the Commission laboratories; (b) Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity

We think the intent of the multiprogram laboratories to shift their emphasis so as to perform basic research and less development and testing is good. As this shift occurs, we would expect some alteration in the personnel composition at the laboratories. We would expect many of the engineers at present in the multipurpose laboratories to move into industrial and nongovernmental engineering organizations; and we would expect, on the other hand, an increase in the number of research scientists at the laboratories.

(c) *Whether greater emphasis should be given to more advanced nuclear research and development projects*

We believe that greater emphasis should be given to advanced research and development projects in the AEC laboratories, and that industrial organizations should pick up the applied engineering projects of current application. As has been inferred earlier, we feel that an environment which convinces industrial organizations that the AEC does not intend to compete with industrial research installations is necessary if the capability of private organizations and laboratories is to develop.

(d) *Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories*

As has been mentioned previously, we feel that the assignment of nonnuclear research to the AEC laboratories must be very carefully approached. It would be a reasonable course only if such nonnuclear research can be performed at the AEC laboratories without conflict with existing nuclear prorgams, if such work will help maintain qualified staffs at the laboratories which would otherwise deteriorate, if such work is in the interests of the national welfare, and if such work cannot be reasonably performed by industrial and other private organizations.

Very truly yours,

DAVID F. SHAW, *Vice President.*

LOCKHEED AIRCRAFT CORP.,
Burbank, Calif., April 27, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR MR. RAMEY: Reference is made to your request of March 15, 1960, for comments on volumes I and II of the document entitled "The Future Role of the Atomic Energy Commission Laboratories" as reported by the U.S. Atomic Energy Commission. Careful consideration has been given to the content of these volumes, and the corresponding comments are given with reference to the numbered items in attachment 2 of your letter.

1. Lockheed Aircraft Corp. is in agreement with the statements concerning the position of the atomic energy laboratories as national assets. Their intersupplemental technical strength cannot be questioned. (The future goals of the multiprogram laboratories, as stated on pages 7 through 8 of volume I, are in general commendable), and we can find no basic objection to these statements. However, under paragraph 3 of these six goals, there appears to be lack of specification of a definite policy as to the point in a research and development program at which industry can be expected to begin to participate.

2. Reference is made to a statement in the first paragraph on page 10 dealing with laboratory, university, and industry relationships. The statement refers to "an orderly progression to industry of development projects undertaken by Commission laboratories. The Commission intends to encourage this progression and to support, through appropriate contracts with industry, such further development as warrants continued Government support." It would seem that a more clearly defined policy with respect to the expression "orderly progression" should be forthcoming. A detailed statement regarding the nature of contracts which the AEC would award to the laboratories and to industry would be welcome.

With regard to the objectives for the civilian nuclear power programs, as stated on page 17 of volume I, it would seem appropriate to indicate the particular areas where industry may be expected to contribute. This also should be done in the case of military powerplants.

3. With respect to the research and development objectives of the Commission laboratories, as stated on page 18 of volume I, there appears to be no disagreement with these fundamental statements. It does seem, however, that, in view of the extensive national program in both the missile and nuclear fields, industry could play a much more significant role in applied research work leading directly to development programs. Such Government support to industry might certainly lie in studies of the basic chemical, physical, and metallurgical properties of materials. It is unlikely that industry would be interested in

basic research associated with controlled thermonuclear problems and application of peaceful nuclear explosives. However, there is much that industry could contribute in the area of radioisotope and radiation technology and associated development programs.

4. There would appear to be no objection to the continuance, within the national laboratories, of work which is associated with weapons development, purely basic physics and chemistry research, studies in biology and medicine, radiation effects, genetics and environmental radiation, radiation protection, toxicological research, cancer research, plant sciences, peaceful nuclear explosive studies, and international cooperation. However, it would appear that research and development on special-purpose reactors and the various civilian types, including sodium-cooled, enriched gas-cooled, heavy water, and aqueous homogeneous reactors should be contracted to industries technically capable of carrying out this work. This also would be true in the case of metallurgical studies and isotopes development. The Commission's policy, as stated on page 65 of volume I, of seeking "to make room for new projects and undertakings in the laboratories by removing from the laboratories work which has been brought to the point where it can be carried on by others," leaves considerable doubt as to the level of technical development of a project at the time it would be given to industry. A more technical delineation of work responsibilities between the laboratories and industry would be desirable.

5. It is certainly essential that the national laboratories be kept up to date by appropriate addition and replacement plans. It is expected, however, that careful consideration would be given to any plans for incremental growth in any particular laboratory so that programs which might readily be contracted to industry would not find their way into these laboratories.

6. The desire of the Commission to increase support of basic physical and biomedical research in the universities, as stated in paragraph 1 on page 66, is commendable.

7. The concern of the Commission relative to maintaining technical competence essential to weapons research and development within the national laboratories, as pointed out in paragraph 1 on page 67, is understandable, but it is not felt that this technical competence should be retained by neglecting support to industry.

8. General comments concerning the planned changes in staff and program emphasis at each of the Commission laboratories are given below for each laboratory.

Argonne National Laboratory.—Plans to increase the reactor development work would tend to affect considerably the number and size of comparable contracts which could be given to industry. Careful consideration might be given to the extent of reactor development work at Argonne. With respect to solid state and physical metallurgy research, it would seem that industry is in a satisfactory position to execute contracts in these areas.

Brookhaven National Laboratory.—The work being carried out at Brookhaven is fundamental in nature and does not in general embody contracts which could satisfactorily be handled by industry. Future growth of this Laboratory is certainly in the national interest.

Oak Ridge National Laboratory.—It appears that this Laboratory represents another instance in which reactor development work, which might well be contracted to industry, is being carried out. On the other hand, research and development associated with chemical processing, controlled thermonuclear reactions, physical science research (with the possible exception of metallurgy and solid state physics), life science and radioisotopes may not materially affect industry's position.

Ames Laboratory.—The basic research programs carried out by the Ames Laboratory are a natural outgrowth of the close relationship of the Laboratory with Iowa State University. However, the extent to which the Laboratory will produce quantities of highly pure metals and alloys is of possible concern to industries in a position to handle that type of production program.

Lawrence Radiation Laboratory—Berkeley.—The type of work being carried out by this Laboratory appears to be in no way opposed to industrial interests.

Lawrence Radiation Laboratory—Livermore site.—It is to be expected that the nuclear weapons development program would remain within the confines of the Laboratory. With respect to nuclear ramjet development, however, although it is expected that ramjet engine production would be given to industry, consideration might be given to the part which industry could play in the earlier research and development stages. Research and development work on a high-temperature, gas-cooled reactor should also fall into this category. We are in

total agreement with the feeling that Sherwood project work should remain within the national laboratory and continue along the presently established lines.

Los Alamos Scientific Laboratory.—This Laboratory has been primarily associated with weapons research and development. The recent plans to place all responsibility for nuclear rocket propulsion work within this Laboratory is disturbing, and we feel that careful consideration should be given to the place of industry in the rocket propulsion program.

The above remarks convey the reaction of Lockheed Aircraft Corp. to the statements of the Atomic Energy Commission, as set forth in volume I of "The Future Role of the Atomic Energy Commission Laboratories," and by the laboratories themselves in volume II of the same document. However, it is realized that we cannot speak for the interests of either the chemical industry or the medical research foundations, and it is quite possible that there are activities covered in the chemical and biomedical fields which may be handled effectively outside of Government agencies. The interests of these other industries should be examined in considering the national atomic industry program.

Finally, we appreciate the opportunity to comment on the contents of these reports, and you may be assured of our continued cooperation in any future deliberations concerning the interrelationships of industry and the Atomic Energy Commission Laboratories.

Very sincerely yours,

COURTLANDT S. GROSS, *President.*

MALLINCKRODT CHEMICAL WORKS,
St. Louis, Mo., April 26, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We appreciate your asking us to comment on the report prepared by the Atomic Energy Commission on "The Future Role of the Atomic Energy Commission Laboratories" volume I and volume II. Since our activities in this general field have not brought us into close contact with the laboratories on a firsthand basis, we do not feel we are in a position to offer any meaningful comments on the specific items listed in the attachment to your letter.

However, in general, we believe that the AEC laboratories should continue to perform basic research and to conduct such related developmental activities as are necessary to carry this work to the point where it can be taken over by industry. It seems obvious that this will require the AEC and industry to work closely and cooperatively in order that there may be successful industrial development in the nuclear field.

We have the feeling that, with the exception of weapons research and development, the AEC laboratories should not continue to expand at the same rate as they did during the last 10-year period. Certainly one way to achieve this would be to involve competitive industrial concerns more closely in this program. We believe that it will benefit by the stimulus supplied by competition.

Yours very truly,

HAROLD E. THAYER,
Executive Vice President.

MALLORY-SHARON METALS CORP.,
Niles, Ohio, May 5, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
U.S. Atomic Energy Commission, Washington, D.C.

DEAR MR. RAMEY: Please accept my apology for not acknowledging before this date, your letter of March 15, 1960 addressed to Mr. F. H. Vandenburgh, president, Mallory-Sharon Metals Corp.

Mr. Vandenburgh resigned as president of this company in October 1959.

You and your committee are indeed to be congratulated for the comprehensive scope of this report. Due to the limited opportunity I have had to study it, I don't feel qualified at the moment to make any comment on it.

With all best wishes,

Sincerely,

E. J. CRONIN, Jr.

THE MARTIN CO.,
Baltimore, Md., June 16, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
The Capitol, Washington, D.C.

DEAR Mr. RAMEY: In response to your request for comment on the report of the Atomic Energy Commission dealing with the future role of the AEC laboratories I am pleased to provide the committee with the following views on items in the list accompanying your letter, numbered according to your list:

No. 1.—In general, the role envisioned for all of the laboratories is progressive and sound. The national laboratories are a great national resource and should be kept strong to do the advanced work which can only be done in such institutions. The university laboratories have a similar relationship to the total national effort, although in much more narrowly defined areas of research.

The constant outflow of research results and data from the Commission's laboratories and their continuing close association with industry, are of vital importance to a strong peacetime atomic energy effort in the United States. A broader base of support and participation by industry in the work of weapons laboratories is desirable, particularly in their nonweapons activities.

The vitality and integrity with which the policy set forth in the definition of roles is applied will be of critical importance. This is particularly true with respect to changes in defense demands on the military-oriented laboratories and the production laboratories. It is a matter of very great national importance to avoid a situation in which the buildup of needed capability in industrial facilities might be slowed or hampered by unwise concentration of work in Government-owned facilities.

No. 2.—The complementary relationship among the Government laboratories, universities, and industrial facilities, as recognized in the report, is a key element in planning the national program of development of atomic energy. The effectiveness of the planning, however, will depend upon the extent to which work, which for reasons of cost or other factors, does not have to be done in Government-owned facilities, is pushed out to industry. It is assumed that the Commission's basic policy objective will be to establish within American industry the maximum capability to meet national goals for the utilization of atomic energy. The Nation's basic strength and power in the world today depends upon the state of preparedness of industry.

No. 3.—The spectrum of research and development objectives outlined in the report focuses attention upon the magnitude and difficulty of the Commission's job, and the list reflects sound program planning. The problem of emphasis in such a broad program, is, of course, a continuing one, but it is complicated by funding procedures and, in the case of those fields of primary interest to the military, by the need to establish firm military requirements for certain major items in order to justify developmental projects. The speed of development and utilization of auxiliary power sources employing radiation energy, and progress in the area of small nuclear power units serve as examples of this problem.

In the field of isotope utilization, in which the Martin Co. has done extensive work, sufficient emphasis has not been given to the full applications of massive radiation sources, a field directly related to the foreseeably grave problem of waste materials management.

No. 4.—The Commission's attempt to anticipate the demands on its laboratories over the next decade brings to light the ever-present problem of maintaining the effectiveness of the weapons laboratories, a defense resource of utmost importance, in case of a radical change in defense requirements. History indicates, fortunately, that new demands will arise which will, to some extent at least, alleviate the problem of trying to continue a program of strengthening industrial capabilities in proper balance and relationship with Government-owned facilities. There is no quick solution to this problem. It is an area of Government responsibility which calls for constant and close scrutiny in order to assure that the Nation's net R. & D. strength is not lessened and that industry's dynamic preparedness to respond to sudden national demands is not impaired.

The solution to the problem depends upon the vitality with which the Commission applies, at all levels of management, the declared national policies, and upon the alertness and sensitivity of the Joint Committee in overseeing the national program. The preparation of this very excellent report is a good starting point and the report should be specifically revised and updated periodically.

In addition to this broad general comment on the section dealing with program trends, we believe that in certain areas, such as specialized reactors, there is a need for more initiative from the developmental side in order to speed the definition of military requirements. The estimates for future development efforts in the uses of massive radiation sources, management of wastes, development of compact and small power units, as examples, do not reflect the degree of emphasis which has characterized the civilian power program for central station generation.

Nos. 5 and 7.—Our comments on these two questions are very similar to our general observations in response to No. 4. Additions to and replacement of facilities at Government laboratories must be carefully evaluated by taking into account both long- and short-range national objectives, the necessarily close relationship between Government and private facilities, and the national importance of strengthening industry for its proper defense role. By virtue of its statutory responsibilities, the Commission must consider the total defense posture as well as the overall scientific and production capability of the Nation. The manner in which the hardware development and manufacturing phases of nuclear defense work is inaugurated and built up in industry is a matter of vital national concern. It calls for specific, immediate, and constant management attention and top-level guidance.

No. 6.—The maximum possible utilization of the talent and resources of the educational institutions of the country, and the consequent growth of those resources, is the only sound national policy and must be the basis of Government planning at all times. Government facilities in the field of basic physics and biomedical research will always be needed, however, in those areas beyond the scope or means of the universities, or for handling projects of such magnitude as would divert and unbalance the educational institutions.

No. 8.—We question the advisability and value of detailed comment, by institution, on the points mentioned under item 8. Our general comments apply to all of the points. We believe strongly that the Government facilities should always concentrate on the advanced work in all fields. This is vital to the Nation's future position of leadership. We have already seen ample evidence, from the intensive scientific effort in many parts of the world since the war, of the value of imaginative and farseeing studies—of research work seemingly far beyond definable results and budgetary justification.

It is our feeling that the expansion of nuclear technology will naturally and inevitably diffuse the unreal barriers existing between nuclear and allied sciences and other disciplines. Organizational and administrative barriers should not determine the areas of work of research institutions such as the national laboratories. Maximum constructive exploitation of the facilities and talents in these institutions and the continuing expansion of that talent pool, quantitatively and qualitatively, are obvious national requirements. The degree of advancement of the work, the efficiency of utilization of resources, human and other, and the contribution to national needs, should determine whether nonnuclear research should be done in AEC facilities.

With respect to the level of effort, including the maintenance of the number of scientists in AEC facilities, we feel the greatest hazard is to permit these laboratories to become static. The multiprogram laboratories, but particularly the national laboratories, are great talent producers and the levels of work or numbers of scientists may even be increased if there is a continuing outflow of trained people who can continue productive work in new opportunities where their training can be utilized. A most important criterion as to level relates to the nature of the work being done, and high levels should not be maintained in Government facilities on "hardware development" work which can be done outside. High levels can be and should be maintained in really basic research and very advanced investigations.

Here again is a problem which can only be solved by constant attention, able and consistent management, and continuing redefinitions and extension of goals, all motivated and directed by the highest recognition of our national purpose and the place of science in our lives. No plan or procedure can be written to solve the problem and enable us to put it aside. It demands continuing attention and unstinting devotion to purpose.

Sincerely yours,

J. DONALD RAUTH.

McLain Rodger Associates,
Downers Grove, Ill., August 8, 1960.

Mr. James T. Ramey,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

Dear Mr. Ramey: I am pleased to submit my comments on the future role of the AEC laboratories as requested.

I was impressed with the analysis of the problems faced by the national laboratories. The Commission and laboratories are to be congratulated on their presentation of their long-term objectives and plans. We need more discussions like this concerning the complex relationships and interactions of the universities, industrial, and governmental laboratories.

In the discussions of the functions of the laboratories presented at various meetings such as the Atomic Industrial Forum and as reported in the newspapers and magazines, the basic problem of industrial versus governmental agency efficiency has not received the attention that I think it should have. I believe that both industrial and governmental agency efficiences are, on the whole, nearly equal today in the United States. Regulations of the Government are frequently stated to result in inefficient operation and frequently this may be true, but I believe that it is no more frequent in Government than in industrial organizations. The statement is frequently made that inefficient Government employees cannot be discharged but the regulations do permit discharge of inefficient employees if proper records and ratings have been made. Industrial concerns have similar difficulties. The obtainment of imaginative and broadly trained personnel is the basic problem in both governmental and industrial laboratories. The measurement of efficiency in both types of laboratories requires continuous study. I believe that in many respects it is almost impossible to set up suitable criteria for judging the efficiency of a laboratory such as Argonne National Laboratory. Some overall knowledge is readily obtained, but is the efficiency of the various individual divisions increasing or decreasing? How do these divisions on a dollar basis compare with those of industrial-operated laboratories doing equivalent work? What are the criteria to be used? I suggest a broad AEC study of the problem.

Both industry and Government are as efficient as their key personnel and group organizations. The Government may tend in some cases to lose their best people since they cannot always meet the salaries offered by industry. While I know of some cases where this has happened in the AEC, the AEC has been able to retain an excellent dedicated staff. The main problem in the laboratories is to create an atmosphere of continuing interest and to maintain high morale.

I believe that the national laboratory and AEC key personnel should be exchanged occasionally. The Defense Department system of officer rotation has much in its favor but I believe this is the opposite extreme to no transfers. It is advisable that the people placed in administrative charge of research and development have considerable experience in conducting these types of work. It is all too easy to confuse action with accomplishment.

One point relative to information sources that I believe is important is that I believe the "need to know" definition can be broadened somewhat. I believe that a number of the scientists and engineers in the country should be given access to the nonweapon information collected during the weapon tests. This would stimulate research and development on the properties of materials at high temperatures and pressures. I do not think that this would require declassification of the data.

Specific comments on the report are presented below:

1. Page xv, paragraph 1: The results obtained with reactor and other projects financed by the Atomic Energy Commission should be completely reported whether or not the work is done in Government or industrial laboratories. Some reports state what was done and the detailed specific technical data are not always covered in complete detail.

2. Page xv, paragraph 2; page 8, paragraph 2; page 67, paragraph 2: Hanford, Savannah River, and Los Alamos are already heavily in the power reactor development program and have been for several years. There do not appear to me to be cogent arguments against the use of these laboratories in the reactor program, but it does appear that the national laboratories have equally good reasons to be in the reactor programs. The Commission should recognize that the plutonium recycle project at Hanford, the heavy water fuel test facility at Savannah River, and the various reactor projects at Los Alamos are

reactor development projects. I recognize that some of the Los Alamos assignments are smaller projects than the EBR II for example, but I do not see how a sharp line can be drawn.

I believe that the Commission needs the Hanford, Savannah River, and Los Alamos experience in fuel fabrication, particularly in respect to plutonium, and I am certain that these groups will do excellent work in the field. Extensive work on plutonium recycle, not on plutonium fuel element manufacture, is described in the new project literature.

3. Page 3, paragraph 3: At the end of World War II a large fraction of the scientists and engineers "drafted" from industry and the universities left the Manhattan District to return to their former positions. It was quite largely the young people who had little or no other postcollege experience that gave the necessary continuity to the project. Many of these younger people deserve great credit for their contributions.

4. Page 4, paragraph 2, under "The Laboratories—National Assets": As noted above, a very significant problem for the Commission as well as for other national agencies that operate large laboratories directly or indirectly is how to measure the "efficiency" of such an installation. I believe this question should be given broad consideration. I agree that much of the Nation's competence in nuclear energy research, development, and engineering exists in the various laboratories, including the three national laboratories.

5. Page 4, paragraph 4: The relations of the national laboratories to the universities is quite direct in many respects, but very poor in others. This area needs strengthening and broadening, particularly in respect to several of the engineering aspects of nuclear energy. I suggest a commissionwide study of what is being effectively accomplished and to suggest wider areas of cooperation. Relations with industry are quite direct as industrial people have specific questions, but it is my opinion that there are many people in the various universities that do not recognize the information available in the laboratories or the services now offered by the laboratories.

I must add that I believe the Atomic Energy Commission as a whole, and this includes the laboratories, has done a very excellent job in respect to education. I believe the Commission is ahead of most other Federal agencies in this respect.

6. Page 4, paragraph 5: The most difficult management problem facing the national laboratories, I believe, is how to attract and hold top imaginative and broadly educated scientists and engineers. In this respect, the laboratories should expand their internal educational and training programs. The laboratories should make a conscious effort to train engineers as reactor project managers. Such men will be needed by the utilities, both private and public, in the relatively near future, 1965–70. I believe that one of the best procedures for the laboratories to follow is the actual transfer of personnel between divisions. This certainly results in immediate and temporary delays in the work, but I believe the broader experience gained by the people who are transferred results in an overall development of the personnel.

I also believe that occasional transfer of personnel to and from the laboratories and the Germantown office is helpful in delineating the programs, as indicated earlier; and this also aids in the training and development of personnel for increased responsibilities.

7. Page 5, paragraph 2, line 8: The statement that "The combination of these features provides the Nation with results beyond those to be expected by devoting the same talent, effort, and proportion of national resources to research and development on other bases," is questioned. Some of the smaller colleges and universities, I believe, have done even better dollar for dollar. This does not argue for disbanding the national laboratories but rather for support of those individuals isolated in small colleges and universities who are teaching and are capable of doing excellent work in particular research and development fields.

My arguments for the laboratories include continuity of personnel on particular projects and the development of real experts in the best sense of the word. The laboratories also can attack broad problems of national interest. As pointed out in the report, they also act as a reserve for advice in case of emergencies, etc.

8. Page 5, paragraph 3: It is stated that, "They are a principal source of new ideas for scientific programs and of suggestions and advice as to the approaches toward which major efforts should be directed." This may very well be true for major projects, but I believe that the universities man for man and dollar for dollar produce more fundamentally new and basic ideas than do the large laboratories or research institutes in the United States. The work of the universities appears to be more dispersed and frequently appears to lack overall direction

or purpose. There may be considerable duplication, but I cannot comment on this. The national laboratories are suited to carry out larger projects than those that can be tackled by universities without large grants-in-aid. It appears to me tht the universities are most efficient in respect to basic research projects that can be carried out with a few people while the national laboratories are best equipped to carry out larger research and development programs, particularly those which require large specialized equipment or "team approach."

I believe that a considerable portion of the work carried out in the national laboratories could be transferred to the universities. To do this I would recommend that the contracts with the universities be coordinated through the national laboratories rather than through the area offices as at present. The reason for this statement is that I believe closer individual and more frequent contacts between the men working on similar projects in the laboratories and universities would result from assignment of responsibility for the contracts to the laboratories. It is not a criticism of the area offices.

9. Page 6, paragraph 1: The statement is made that the laboratories constitute a reservoir of talent and experience. This is true. I also personally believe we need all our present institutions. We should be opening others for specific fields, such as new energy sources and high-temperature materials development.

10. Page 6, paragraph 2: I agree that the cooperation of the universities, laboratories, and industry has been very succesful in many respects on large projects.

11. Page 7, paragraph 1: "Advancing the frontiers of knowledge in the sciences is a basic mission of the Commission and is the grist from which application-type projects are derived." The first part of this is also one of the main functions of the universities. I personally believe we need to open more universities. University professors are frequently burdened with excessive committee work that should be done by trained administrative people (or forgotten in many cases). Lower teaching loads and increased analysis should be asked of these people.

12. Page 7, paragraph 2: I believe that other laboratories should be brought into the weapons technology development to spark new ideas and foster new and widely different weapon developments. In addition, I believe the national laboratories can contribute to development of nuclear missile propulsion systems. In other words there has been, and I believe exists today, too little interchange of ideas between the national laboratories, production plant laboratories, and the weapons production laboratories. While this involves need to know, I believe that there should be increased discussions.

13. Page 7, paragraph 3: The laboratories are not as well equipped as the universities to suggest new ideas. The thought processes of a professor trying to tell an integrated story are ideal for suggesting new points of view and new areas of research. When one does this or when one tries to write a textbook or monograph, he recognizes the unknowns and wishes to fill in the gaps. The stimulus of directing graduate students and directing graduate seminars also suggests many lines of research by indicating gaps in our knowledge. Much of the work of the national laboratories consists of making detailed measurements which are not really basic research. However, this is important work.

In this same paragraph the question of economic worth is mentioned. This is a very questionable assignment to the laboratories.

14. Page 7, paragraph 4: The utilization of the laboratories for special urgent tasks is probably their most important function. They consist of a reservoir of trained and skilled personnel who can attack research and development tasks in groups. This ability or reservoir is largely lacking in university groups. An example is the hydrogen bomb project work assigned some years ago to Argonne National Laboratory.

15. Page 7, paragraph 5: I applaud these statements which refer to the role of the laboratories in broad cooperative programs.

16. Page 8, paragraph 1: In reference to technical evaluations and advice, I believe that the Commission should seek broader evaluations. When needed some university and industrial people as well as laboratory personnel should be assigned to evaluations.

17. Page 8, paragraph 2: As noted, I believe that some of the information developed in the military programs has not been made available to the other laboratories. I believe some of these data could be made available for nonmilitary use within the general framework of need to know, thus making the information

available for integration into the entire scientific and engineering fields. Perhaps this would eliminate some of the duplication in work within the various installations.

18. Page 9, paragraph 2: The statement is made that the universities, industry, and laboratories have complementary functions. I believe this is so. I believe that industry has claimed for their field some work which the laboratories could do better. I also know that the laboratories have done considerable work that could have been done by industry. The laboratory managements have to decide what work can be transferred to industry when it may result in delays and loss of overall efficiency. This is a difficult assignment.

I believe that the most significant improvement that could be made is the strengthening and improved relations between the laboratories and universities. In my opinion, this could be aided most by transfer of the administration of the contracts from the area offices to the laboratories.

19. Page 11, paragraph 3: Again, I repeat all industrial work paid for by the Commission should be completely reported. This refers to development and research work.

20. Page 11, paragraph 5: The national laboratories should consider training one of their prime functions (as they do) and should foster loss of trained personnel to industry and universities.

21. Page 14, paragraph 2 (lines 9–12 from top of page): I believe that the Commission should continue and broaden its investigations of ore upgrading methods. Any reasonable ideas in this field should be vigorously supported.

22. Page 14, paragraph 4 (bottom of page): As noted above, I believe more organizations should be brought into the weapons development and weapons production programs. The work in basic ideas for new weapons should be expanded. I would like to see the AEC establish an organization corresponding to Rand.

23. Page 15, paragraph 1; page 30, paragraph 1: In my opinion the maritime reactors development has been slow. I would recommend that two or three more ship reactors to propel large ships be authorized immediately. These should be designed to give long fuel life.

24. Page 17, paragraph 2 (under "Civilian Reactors"): It is rightfully an objective of the Commission "to achieve competitive nuclear power costs?" I do not think so. I believe that the Commission should develop those reactors that have the best potential to the point that the technical problems are solved but not necessarily until the reactors are economic. I believe the Commission should not enter the large power reactor program as the Commission has other uses for its resources. Let the public and private power groups carry out the economic large-scale construction. The Commission should not in my opinion continue operation of such reactors as the Shippingport reactor beyond the point at which the costs equal the value of the technical information developed.

25. Page 23, paragraph 1, line 5: The statement is made that the use of radioisotopes is relatively unexploited. There are a number of companies in this field and many companies are conducting development programs. I believe that the Commission could aid the program by making available large gamma sources and various separated fission products as it plans to do. I believe that this is as far as the Commission should go. There are many applications of radioisotopes today and the field will have a normal growth if left alone. However, I think that the Commission should continue its educational programs in respect to the use and handling of radioisotopes.

26. Page 35, paragraph 4: I do not understand why there is so much sudden interest within the Commission on the use of plutonium in "water reactors." This problem has been recognized for years. Certainly the work at Argonne, Hanford, and Los Alamos on development of handling techniques, plutonium alloys, and fuel elements is justified, but I believe this is sufficient.

The development of fast reactors has, in my opinion, not been pushed rapidly by the Commission. But I do not believe that more programs should be authorized—only that those now underway should be given more complete support.

27. Page 37, paragraph b: Under reactors I believe that the country needs two or three more modernized MTR or CP–5 type reactors and at least one reactor for very high fluxes (such as those being worked on at Argonne and Oak Ridge). The MTR is so overloaded that many of the tests being run have low value due to the necessarily large flux variations with the present heavy test loads.

28. Page 65, top paragraph: I personally believe that the top efficiency of the national laboratories occurs around 2,000 to 2,500 employees. I think that it

would be more beneficial to open additional laboratories rather than expand the present ones to 4,000 to 5,000 employees.

29. Page 65, bottom paragraph: The statement is made that the laboratories will remain paramount as "inventors and developers of new concepts." While this statement is heartily applauded we should also foster "inventions" in the universities and industrial laboratories.

30. Page 69, paragraph 1: While I am not experienced in the accelerator field, I do not understand the need for so many large ones. More test facilities and analyses of the data are required and accelerators of different energies and built for different particles may be needed but not duplicates.

While not specifically mentioned, I believe the national laboratories should expand the engineering talent placed on the fusion programs. I believe that the work could be expedited by increased emphasis on "development laboratory" techniques.

The above statements are all personal opinions. I hope that they may be of value to the committee and that they may lead to further discussions in respect to some of these problems.

I believe the national laboratories are doing excellent work and that they are as efficient as the industrial operated laboratories.

Respectfully submitted.

STUART MCLAIN.

OLIN MATHIESON CHEMICAL CORP.,
May 18, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In response to your recent request for comments on the future role of the AEC laboratories, we have reviewed the Commission reports to your committee, volumes I and II. In view of the broad scope of this report we are limiting our response to the eight areas attached to your letter, and, because of the limited nature of our present corporate program in the nuclear field, we have restricted our opinions primarily to those in which we feel we have some direct experience. In general, it appears that our position may not differ greatly from that of other industrial concerns engaged in comparable activities in the nuclear energy field. These activities have been for the most part limited to production of naval reactor cores for both submarines and surface vessels, and to applied research on fuel element materials such as uranium oxides and carbides.

With respect to the eight areas indicated as being of special interest to the Joint Committee, we have followed the format suggested by your letter.

1. *Future role of Commission laboratories by class.*—We are in agreement with the Commission that the laboratories are today a vital and necessary part of the Nation's assets and that within the conceptual framework of the role of the laboratories as a medium for extending knowledge and performing basic work in energy applications there are strong reasons for sponsoring these laboratories.

Both the multiprogram and the specific purpose laboratory objectives appear to be well-defined, particularly in respect of areas of work which would not only not be of general interest to industry, but would also, in many cases, be impossible of attainment in most industrial laboratories.

2. *Policies for cooperation with universities and industry.*—The stated policies with respect to the Commission support of projects in university facilities and the orderly progression of development projects to industry are in substantial agreement with our own interest which includes, in addition to manufacture of hardware and specific R. & D. proposals, the need to obtain many types of information not directly associated with current contract items in order to provide an adequate and reliable background for future corporate planning and expansion in those areas of nuclear energy application which appear to offer a potential industrial market.

The stated goals of the various programs (pp. 9–17) have undoubtedly been carefully considered by the Commission with respect to the Nation's needs. Our own specific experience is so limited as to preclude any recommendations for additions or changes at this time. It is, however, in our opinion to be anticipated from the broad nature of these programs that much of the work requested will

lend itself to contracted projects with experienced industrial personnel and facilities.

3. *Research and development objectives (pp. 13–26).*—These objectives are generally of the utmost importance and much of this work must be considered basic in nature. Basic work is best performed in the AEC or university laboratories by appropriate support since the facilities required are not usually available in industrial laboratories, or if available, the objectives of a particular project at the basic level may be too limited to develop sufficient interest in industry. The main problem in assessing the R. & D. objectives is the definition of what constitutes basic work, as opposed to R. & D. work having direct application to areas of applied technology with apparent industrial potential.

Since it is apparent that broad R. & D. objectives may overlap, the only control on a national basis is control of annual budgeted expenditures. Obviously if these expenditures are budgeted correctly in relation to the total national effort (both governmental and industrial) there will be a healthy situation of enterprise in all areas. Periodic reviews of the situation, such as the present inquiry, are a healthy and desirable condition.

Our own experience with Commission sponsored R. & D. programs has been rewarding, not only in work undertaken, but additionally a point of particular interest has been the sharing of information with other contractors and the Commission laboratories. These projects are contributing greatly in this case to our general awareness of ceramic fuel problems and technology, and broadening our contacts and interests in the nuclear fuel industry.

4. *Estimates for changes in work, etc.*—We have no specific recommendations with respect to the strength or level of effort proposed for the Commission's R. & D. program. Generally, it can be observed that the nuclear industry is considerably more competent at present to improve production processes than it was a few years ago, and, in fact, is continually involved in this phase in order to reduce its own operating costs. This can be of such importance that applied development of this kind may in appropriate cases be privately financed by industry.

5. *Future facility addition.*—We believe that additions and budgeting of Commission laboratories can best be determined by others.

6, 7, and 8. *Basic physics, etc.*—We have no direct experience in these fields which can be applied to these questions.

Very truly yours,

E. HARTSHORNE,
Vice President, Nuclear Fuels Operation.

RADIATION COUNTER LABORATORIES, INC.,
Skokie, Ill., April 1, 1960.

Re Future role of AEC laboratories.

Mr. JAMES T. RAMEY,
Executive Director,
Congress of the United States,
Joint Committee on Atomic Energy
Washington, D.C.

DEAR MR. RAMEY: The two reports outlining the role of the AEC laboratories were well prepared. It is believed that the future of the national laboratories will contribute to the welfare of the United States. However, there is no real force within the AEC to have work done, much more economically, by private companies than by the national laboratories. The indicative assertion is the effective forthcoming growth which is shown in all of the instrument departments in each of the national laboratories.

Today the nuclear instrument industries, as Dr. Weinberg remarked in his letter of March 17, 1960, is both capable and competitive. The above is indicative of an area where expenses should have very close review. Another area which requires close surveillance is the Argonne National Laboratory machine shop located in a metropolis such as Chicago. Chicago, as you know, is known for its many excellent private machine shops.

Thank you for sending the above reports to me and keeping me informed of the progress of the AEC.

Sincerely yours,

ERNEST H. WAKEFIELD,
President and Director.

OAK RIDGE NATIONAL LABORATORY,
UNION CARBIDE NUCLEAR CO.,
Oak Ridge, Tenn., March 17, 1960.

Dr. ERNEST H. WAKEFIELD,
Radiation Counter Laboratories, Inc.,
Nucleonic Park, Skokie, Ill.

DEAR SIR: The continued need for information on the time and energy correlation of multiple nuclear events in a variety of experiments in nuclear physics has generated a trend toward analyzers of larger capacity in much the same manner as single channel analyzers were superseded by multichannel analyzers for energy or time analysis. At ORNL there are at least two experiments involving multidimensional analyzers. One is a fission fragment experiment requiring a 10,000 channel analyzer and the other a neutron capture gamma-ray experiment requiring a 2,000 channel analyzer.

It is our opinion that the widespread use of pulse height analyzers has created a nuclear industry that is both capable and competitive. In the past we have purchased all analyzers on a set-bid basis and it, therefore, seems to us that a deviation from our previous practice of buying on a set-bid basis would establish a bad precedent. Incidentally, you may be interested to know that several nuclear instrument companies recently have expressed interest in building, at a set price, multidimensional analyzers of the type described in your letter.

Sincerely yours,

ALVIN M. WEINBERG.

SARGENT & LUNDY,
Chicago, April 27, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We have reviewed the subject material contained in the two volumes, "The Future Role of the Atomic Energy Commission Laboratories," over the next 10 years, forwarded with your letter of March 15, 1960, and have also considered the specific items included with your letter concerning which comments are requested.

The reports bring out that the broad interests involved in the future role of the Commission laboratories in research and development as they relate to atomic energy are: (1) national defense and security, (2) public health and safety, (3) nonmilitary activities, and (4) the private enterprise system.

From these reports, one is impressed with the national asset aspect of the Commission laboratories. One also gains a general comprehension of their overall scope which serves as a broad backdrop for comment and which can be summarized as follows:

(1) Expenditures for nonweapons research and development for the current fiscal year is $625 million.

(2) Expenditures have been increasing over the past 5 years at an average rate of $85 million per year.

(3) Some 20 establishments are supported with a total personnel of approximately 41,500, of whom 11,500 or 28 percent are scientists or engineers.

(4) Completed laboratory plant and equipment exceeds $1 billion.

(5) Based upon the current fiscal year, expenditures are at the rate of about $55,000 for each scientist and engineer with plant and equipment equivalent to approximately $100,000 for each scientist and engineer.

In our comments which follow, we would like to point out they are based essentially on the information supplied in the two volumes mentioned above and not necessarily on our knowledge of the activities carried on at each of the 20 laboratories covered in the reports.

As a general comment, we believe that in the interest of national defense and security and in the interest of public health and safety, the Commission laboratories should continue to carry on a broad program of basic research and development geared to both national and international requirements. Further, in order to maintain and strengthen the private enterprise system, emphasis should shift, in a well planned orderly progression consistent with the requirements of national defense and security, from Commission laboratories to industry and universities for that research and development classified as, (1) applied research and general development, (2) project development and (3) process and product development. And where these latter types of research are sup-

ported with Government funds, the research information obtained should be made available for civilian use to the widest extent practicable.

In commenting on the list of specific items, the item has been repeated for convenience.

Item 1. The future role of Commission laboratories by class

Comment.—We are in general agreement with the Commission's outline of the future roles of its laboratories, which we understand, in brief, to be—

(*a*) Multiprogram laboratories to be maintained as vigorous and broad research and development establishments;

(*b*) Project engineering laboratories to support specific military projects as their primary mission;

(*c*) Production plant laboratories to improve production processes. Further the Commission does not plan to develop these facilities as multiprogram laboratories;

(*d*) University laboratories will be continued and supported by special purpose research facilities and with projects for which these institutions have special qualifications and capabilities.

Item 2. Policies for Commission cooperation with universities and industry

Comment.—We agree with the Commission policies on this item, which we understand to be: A shift of emphasis from Commission laboratories to university and industry facilities for such research and development work as they are capable of doing with an effective flow of technology to private industry.

Item 3. Research and development objectives of the Commission laboratories

Comment.—Bearing in mind the shift of emphasis to industry and universities outlined above, we are in general agreement with the Commission's stated research and development objectives for: (1) Materials supply, (2) weapons development, (3) maritime reactors, (4) civilian reactors, (5) physical research, (6) controlled thermonuclear research, (7) biology and medicine, (8) peaceful nuclear explosions, (9) isotope development, and (10) training.

Item 4. Estimates of changes in work and level of effort in Commission research and development programs

Comment.—It is difficult to make a meaningful appraisal, from the information at hand and the time available, of the future workload that should be assigned to the Commission laboratories. From the forecast of programs in the several areas of research and development the trend as a whole is an increasing one. It will take competent management and administration to keep this trend in line with the sentence included in the summary and conclusion, page 63, which states, "Barring unforeseen program changes, this trend should be at a rate related to the growth of the national economy and the overall scientific potential."

Item 5. Future facility addition and replacement plans at Commission laboratories

Comment.—We are in general agreement with the following statements of the Commission as they rotate to the above item: "The Commission plans an orderly replacement of temporary structures which house permanent laboratory activities." "With some specific exceptions, the facilities and the staffing of the laboratories appear to be equal in scope to the responsibilities that lie ahead for them." "It is the judgment of the Commission that growth of the large multiprogram laboratories beyond the 4,000 to 5,000 level may well lead to cumbersome administration and, therefore reduced effectiveness. The Commission, as a matter of policy, will seek to make room for new projects and undertakings in laboratories by removing from the laboratories work which has been brought to a point where it can be carried on by others."

Item 6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories

Comment.—We would approve of the above plans and the overall benefits to be gained as covered by the following statement of the Commission: "Research at the universities yields as a byproduct the training of additional scientists—essential to staff the growing demands of research and development institutions throughout the economy and to maintain the United States in the forefront of scientific and technical affairs."

Item 7. Commission's intent to consider maintaining the strength of weapons laboratories by expanding nonweapons work at such laboratories if necessary

Comment.—We agree that those laboratories essential to weapons research and development—Los Alamos, Lawrence at Livermore, and Sandia—be maintained as strong and vigorous institutions. We question the wisdom of assigning nonweapons functions at these laboratories to offset any decreae in weapons research and development, particularly of the "make work" variety in order to maintain the staff. At this time, it does not appear that in the 10-year period under consideration there will be any significant letup in weapons research and development. If it should occur, rather than assigning nonweapons work, to maintain the staff, we feel the judicious placement of personnel, if necessary, at other laboratories would be a better solution to the problem.

Item 8. (a) Planned changes in staff and program emphasis at each of the Commission laboratories; (b) whether maintenance of the present number of scientists and level of effort for the various laboratories results in the most efficient operation and greatest scientific productivity; (c) whether greater emphasis should be given to more advanced nuclear research and development projects; (d) whether work in fields of non-nuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories

Comment.—The four subitems listed under item 8 all touch on personnel and program matters. To comment on these specifically with any significant degree of meaning would require an intimate knowledge of the operations and personnel at each of the Commissions laboratories. Therefore, lacking this intimate knowledge the comment can only be generalized. Our generalized comment is as follows:

(1) Laboratory programs should give emphasis more and more to broad fundamental research, i.e., Commission laboratories should so to speak, "reach for the sky." This would include more advanced nuclear research and development.

(2) Increased research in the fields of biology and medicine as they relate to atomic energy phenomenon would seem warranted.

(3) Training of scientific personnel and dissemination of information for civilian use should have a high place in the Commission's programs. This would include an increase in university activities and a step-up of employment, particularly vacation period employment of graduate, post graduate and teaching personnel.

(4) It is questionable as to whether nonnuclear research should be performed at Commission laboratories. Exceptions to this would be assignments from other governmental agencies, emergency situations and closely related research in the fields of biology and medicine with respect to public health.

In conclusion, the reports present a very comprehensive picture of the role of the Commission laboratories in the next 10 years. We recognize the difficulties of forecasting the activities of the laboratories for a decade ahead and setting policies to achieve the goal set. In order to assure a positive direction of the whole program, it is suggested that to meet these goals specific programing be done on a short-range basis, 1 to 3 years, with the broader objectives set to a longer range basis, 5 to 10 years.

In reviewing these reports, we gained substantial knowledge of the present activities of and future plans for the Commission laboratories and, therefore, wish to thank the Joint Committee on Atomic Energy for soliciting our comments.

Very truly yours,

R. D. MAXSON.

STONE & WEBSTER ENGINEERING CORP.,
Boston, Mass., April 13, 1960.

Mr. JAMES T. RAMEY,
Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: At your request, we have considered your letter of March 15, 1960, and the Atomic Energy Commission report entitled "The Future Role of the Atomic Energy Commission Laboratories," in two volumes. Following the outline of specific items concerning which you requested comments, we are pleased to present our views in this letter.

As to the future role of the Commission laboratories, one point is obvious. The laboratories are there, and they are going concerns. In spite of the criticism the AEC has received concerning competition with private enterprise, it would be destructive in the extreme to consider abandonment or rapid reduction in size of these laboratories and curtailment of their activities. On the other hand, it would also be unwise to consider significant expansion. We believe that the amount of scientific work connected specifically with atomic energy will expand and that the proper policy would be to place as much of the overflow as possible into other hands, particularly universities, without attempting to meet the demand by expansion of the Government-owned laboratories. As we understand the AEC report, we believe that this is the proposed policy.

The stated policies of cooperation with universities and industry appear to be entirely acceptable. In deciding whether to cooperate with universities or industry, it should always be borne in mind that industry has commercial objectives and has been established to make money. For this reason, the objectivity of industrial work is sometimes in doubt. Contrasted with this, however, the university may sometimes lose efficiency because of the lack of commercial drive. To generalize, basic research would belong in the university, with applied research, perhaps, being carried out more effectively by industry, especially if a competitive motive can be established and the chance of profit can be made real.

The research and development objectives of the Commission laboratories appear reasonable. However, we would restate the remarks we made in our letter dated September 28, 1958, in which we commented on the proposed expanded civilian nuclear power program. In this regard we pointed out that the chemical engineering field depends for its success in learning certain techniques known as unit operations, for example, mixing, grinding, evaporating, heat transfer, distillation, and electrolysis, and that a group skilled in unit operations could construct almost any type of chemical plant and devise entirely novel plants without any previous experience in their design, operation, or construction. We stated that this approach should be helpful in the development of competitive nuclear power, and that the AEC would do well to approach atomic energy from this viewpoint. Our principal criticism of the programs which have been carried out so far, some of which are mentioned in the report, is that they are at times too subjective.

The changes in work and the level of effort in the Commission research and development programs, as explained in this report, show increasing efforts until 1960, largely because of newly installed facilities, such as exemplified by the Alternating Gradient Synchrotron at Brookhaven. It is entirely reasonable that these new facilities should be employed, but we believe that further expansion of the laboratories should be approached with utmost caution.

We are heartily in favor of greater increases in work on basic physics and biomedical research at universities rather than at Commission laboratories.

It would also be only prudent to maintain sufficient strength in the weapons development laboratories by taking on nonweapons work, if necessary, provided that this shift of activity is carried on without expanding these laboratories. In fact, it should be possible to reduce the total number of personnel and the total activity to the lowest level that could be expanded rapidly in case of sudden military need.

The planned changes in staff and program emphasis at each of the Commission laboratories appear to be reasonable, but again we would suggest that the maximum amount of new work should be placed outside of the Commission laboratories, that physical facilities should not be unduly expanded, and that nonnuclear work should not be taken on unless a new circumstance arises which would be tantamount to conversion of the Atomic Energy Commission into some other type of Commission. For example, we think of space travel and communications. In all events, the setting up of consulting scientific organizations of the U.S. Government to compete with existing commercial organizations would be a grave error. The proper field for the U.S. Government is in dealing with those aspects which have no commercial appeal but which are supported by the interest of the general public.

We would again suggest that the most serious concern the Commission and the Joint Committee have is the difficulty of propagating the knowledge developed at the Commission laboratories. While there is a veritable flood of literature, some vital information is either not published or unavailable for nonmilitary use because of claims concerning national security, as exemplified by much of the technique on submarine reactors. Some information is not channeled to the general public but sent through channels benefiting only a few. Other information is not published in sufficient time to be fully useful.

It would appear to us that the U.S. Atomic Energy Commission should have a suitable budget to cover the publication of articles, technical papers, textbooks, and brochures so as to make the efforts of their laboratories as useful to as many workers in the atomic energy field as possible. The four technical progress reviews now being published are much to be commended and exemplify what is needed.

Yours very truly,

C. T. CHAVE,
Chief Engineer, Nuclear Projects.

TEXAS INSTRUMENTS, INC.,
April 30, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR MR. RAMEY: We welcome your request for our comment upon the future role of AEC laboratories. Also, we commend the Joint Committee for the effort which it is making to define and maintain the proper role for the Government laboratories. Our remarks are arranged in two groups. The general ones are included in the following paragraphs. Our specific views on the subjects covered in the supplement to your letter of March 15, 1960, are included in the attachment A to this letter.

Throughout the report, "The Future Role of the Atomic Energy Commission Laboratories," there is general recognition of the need for cooperative efforts by the Commission laboratories, industry, and the universities to produce a sound and productive national effort in the field of atomic energy. Several attempts are made to define Government-industry relationships, the most common being that the laboratories will carry a concept through to the prototype stage or until the unit can be manufactured economically. It appears to us sometimes that Government laboratory projects have gone beyond a reasonable transition point. We understand, in most of the cases, that the action is done as a matter of expediency or under a liberal interpretation of prototype development.

We realize the difficulty of continually defining the point at which program transition should take place from Government laboratories to industrial development. It is urged that the Joint Committee and the AEC develop a continuing monitoring system for determining that the general intent of the role of AEC laboratories is carried out in practice. It may be necessary that such monitoring system include a specific instruction from Congress that a certain percentage of all the research and development funds authorized by Congress for atomic energy be expended in laboratories of industries and universities and that this percentage increase on a preplanned basis each year as the center of gravity for research logically shifts from Government to industry over the coming years. It seems desirable to have specific annual goals which achievement can be measured to assure that the intention of Congress is put into practice.

Several references are made in the report to simplification of fuel element fabrication techniques and lower fuel fabrication costs as proper objectives of the AEC laboratories. We believe this work should be left largely to the fuel fabrication industry. Private industry is most familiar with the processes used today and how they can be improved. There is already a substantial industry investment in professional people and plant and equipment to conduct this work at a sophisticated level. Also, industry will have the responsibility for producing the fuels which are to be used in the future. It seems wise to us to develop industry's capability as early as possible and also to be sure, at an early point, that the practical considerations of fabrication by industry are incorporated in any development program. The AEC has recognized this principle by establishing the fuel cycle development program which is supporting private industry research and development in fuel fabrication. We would like to encourage a stronger leaning in this direction.

The objectives of the project engineering laboratories and the production plant laboratories indicate some concern on their part for the future. They list several "nonweapon" alternative roles which they can plan in addition to their primary assignments. We recommended to the Commission the removal of this uncertainty about the future by carefully defining the future programs of these laboratories and providing limited subsidiary objectives in specific fields only

where necessary for a level of activity consistent with the overall direction of these laboratories. Certainly programs which could better be handled by private industry research and development should be avoided.

There is no question but what a successful commercial nuclear industry based on technological excellence would enhance the position of the United States in the eyes of the world. A solution of the future role of the AEC laboratories which would contribute to such a position seems highly desirable. If there is any way in which we can assist the Joint Committee, we shall be glad to do so.

Sincerely,

P. E. HAGGERTY, *President.*

ATTACHMENT A—COMMENTS ON SPECIFIC ITEMS IN THE COMMISSION'S REPORT ON "THE FUTURE ROLE OF THE ATOMIC ENERGY COMMISSION LABORATORIES" DATED JANUARY 1960

1. The future role of Commission laboratories by class, pages 6–9, volume I. The establishment of four classifications of national laboratories seems well conceived since it offers specific concentration on certain programs as well as a broad approach to new or less clearly defined programs. However, the primary mission concept for the project engineering laboratories and the production plant laboratories is clouded by reference to "additional assignments." The programs submitted by the laboratories in volume II amplify this desire for additional assignments outside the defined objectives. The role of each classification as defined in pages 6–9 could be more specific.

2. Policies for Commission cooperation with universities and industry, pages 9–17, volume I. We would like to have the policy broadened to include statements in the maritime, special purpose and civilian reactor programs covering the point at which the laboratories would turn the program over to private industry for further process development.

3. Research and development objectives of the Commission, pages 13–26, volume I. These objectives are reasonable and well delineated. One objective which is not stated is the efficient separation, storage, and use of nuclear wastes, but we are sure that work is currently being conducted in this area.

4. Estimates of changes in work and level of effort in Commission research and development programs, pages 27–63, volume I. We have six comments on this subject:

(*a*) Production process improvement. The "some reduction in the level of effort" seems to be rather conservative. From our viewpoint it appears that one can reach a level of efficiency in plutonium production above which costs to achieve further efficiencies would rise astronomically. We would expect this level to be reached soon. This would allow major cuts in the funds allocated to plutonium production development.

(*b*) Manned aircraft. Similarly, it would seem that an upper limit may be reached soon in the amount we are willing to spend on development of manned nuclear powered aircraft, especially where the end result will be a proof of principle rather than a flying model. Thus, our opinion would be that expenditures in this area should not continue to rise.

(*c*) Military powerplants. It is disappointing to see expenditures will only rise "as necessary" in the field of military powerplants. This area appears to offer opportunities for economic utilization of nuclear power much sooner than most civilian applications. Why don't we take advantage of these opportunities to install economic plants and make profitable modifications on these existing intallations?

(*d*) Civilian reactors. It is encouraging to note that the AEC foresees continued increasing commitments in research and development for civilian reactors.

(*e*) Metallurgy and materials. The projected expansion in effort and funds for metallurgy and materials research is recognized by all to be necessary and desirable. However, we hope that the AEC will take advantage of existing technology and facilities within universities and industry to develop knowledge in these fields. In the past the Commission laboratories have expanded into fields where industrial laboratories and development groups probably have available technology and facilities.

(*f*) No mention is made of the commitment of funds and effort in the area of waste separation, storage, and use. It is necessary that increasing effort be

devoted to these problems over the next 10 years to provide for the increasing amounts of waste that will be generated during this period.

5. Future facility addition and replacement plans at Commission laboratories. Certain facility additions listed or mentioned in volume II appear to be duplication of facilities available in industry. Continual vigilance is necessary to avoid duplication.

7. Commission's intent to consider maintaining the strength of weapons laboratories by expanding nonweapons work at such laboratories if necessary, page 67; volume I. A program of this kind requires careful management to avoid maintaining the strength of these laboratories possibly at the expense of development of private laboratories. It further means that the AEC laboratory system may continue to grow despite varying requirements for its services.

8. (*a*) Planned changes in program staff and emphasis at each of the Commission laboratories, volume I, part II, starting page 71. The general trend of rapidly increasing funds for basic physical and biological research and level or declining expenditures for reactor development seems in keeping with the desires of the Commission to do basic and applied research and turn over to industry those partially and fully developed programs which can be done economically outside the laboratories.

(*b*) Whether maintenance of present numbers of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity. Efficient operation and scientific productivity at the national laboratories can only be maintained if there is a pressing need for new research and development related to the skills represented. When a program is completed without a new and challenging program to follow, the efficiency of a laboratory group suffers. This places an additional burden on the laboratory when it is adding personnel. Proper long-range planning may show that increased placement of development work with industry will alleviate the need for hiring to complete a specific program and then having to lay off specialized personnel.

(*c*) Whether greater emphasis should be given to more advanced nuclear research and development projects. This definitely should be an objective of the laboratories. They are the ideal group to conduct such programs since they can undertake a long-range program with relatively good assurance of continuous funding and steady employment.

(*d*) Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories. Two unique considerations led to the establishment of our national laboratories. First, the objective (atomic weapons) were so enormous in scope that no one company or university group could control the program that had to be undertaken. Second, the materials involved and tests to be conducted were potentially very dangerous. For these reasons than, the United States established a laboratory system which we had not required until the 1940's.

We believe these same general criteria should be applied to any new programs the laboratories could undertake. The laboratories should not undertake special projects just to make work or utilize facilities. There are several universities, nonprofit, and industrial laboratories that could and should do this type of work. Only if the program is so unique as to require Government laboratory sponsorship, would it seem proper to utilize the AEC national laboratories even though the work may be nonnuclear in nature.

WESTINGHOUSE ELECTRIC CORP.,
Pittsburgh, Pa., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In response to your letter of March 15, I have few comments to offer on volumes I and II of the report entitled "The Future Role of the Atomic Energy Commission Laboratories." The report is an excellent review of the various laboratories, their objectives, areas of interest, operations, and future plans. The constant developments and changes which take place in the atomic energy field might make it worthwhile to update this report from time to time.

I am pleased to see the statement of philosophy of continuing to place increased responsibility on industrial organizations "to perform Commission-supported development, as the nuclear energy field progresses toward commercial application and as private organizations acquire capability in facilities and personnel," and also to note the policy to promote "the participation of industry in the nuclear field on an increasing scale and to transfer to industry, as industry indicates its capability to perform, operations or functions now being performed in Government facilities."

The recognition of the roles of the laboratories and private industry is well stated in the report. On the matter of industrial participation, the report might be strengthened if the central role played by the universities and industrial companies in operation of the Commission's laboratories were further emphasized. These operators have built and maintain the strength of the laboratories through the skilled management and technical personnel which are transferred into the laboratories. Also, industrial contractors provide a substantial fund of information on business and management systems and techniques and industrial know-how in research, engineering, and manufacturing. I am sure that these contributions have been and will continue to be most important to the success of our laboratories.

Sincerely,

CHARLES H. WEAVER, *Vice President.*

APPENDIX IV

COMMENTS RECEIVED FROM EDUCATIONAL INSTITUTIONS

ASSOCIATED MIDWEST UNIVERSITIES,
Lemont, Ill., April 28, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In your letter of March 15, you invited comments and views on the subjects covered in the report "The Future Role of the Atomic Energy Commission Laboratories," including comments on designated statements in the Commission report.

The interest of Associated Midwest Universities in the report and the subjects covered therein falls most naturally on the role of the AEC laboratories in relation to the universities, and quite specifically on the Argonne National Laboratory, because of our unique association with that Laboratory. Please recognize this viewpoint which pertains in the general comments and in comments on the specific statements.

The report itself has treated a very difficult subject in a comprehensive fashion. It covers a wide variety of questions with consideration for many viewpoints. In accomplishing this broad result, however, it fails to emphasize the role which is of paramount interest to AMU—the role of the national laboratories in the eductional system.

This question was treated by Dr. Warren C. Johnson, Chairman of the General Advisory Commitee, U.S. Atomic Energy Commission, in his address before the American Nuclear Society at Washington, D.C., on November 6, 1959: "As soon as the multiprogram laboratories fail to interact with the universities, they will tend to decay and if these laboratories should be unavailable to the universities, basic science in the country will thereby suffer. The opportunity for interaction, as expressed here, is, in my opinion, the most important reason for the existence of the multiprogram laboratories and for maintaining them as strong institutions, not only for the atomic energy program per se, but for the general health of science in the country as well."

At the Argonne National Laboratory, the Zero Gradient Synchrotron seems well on its way toward becoming a national laboratory in high energy physics in the true sense, being a large central facility whose use is shared with the surrounding universities. Similarly, there has always been a widespread university interest in other facilities at Argonne, particularly in nuclear engineering, the use of which would supplement the programs in the universities of this region. In the past, the pressure of AEC program interests and other factors have, in effect, limited the availability of Argonne facilities to the universities. Some years ago, the relationship of the universities to Argonne was characterized as "passive" on both sides.

A clear, emphatic, and unequivocal statement by the Government of the important role to be played by the national laboratories as an adjunct to the universities would encourage educators to find a way to exploit the laboratories. It would help to clarify for personnel within the laboratories, the relative importance of their own research and development projects and those cooperative ventures involving universities.

We have carefully reviewed the specific statements in the Commission report on which you invited comments. This review produced no important criticism of the statements, possibly because AMU is a relatively new organization and our experience is limited. AMU has received significant support and encouragement from the University of Chicago and the AEC in our initial efforts. Comments from many university people indicate progress. We feel that these statements are in general compatible with our future success.

Sincerely yours,

JOHN H. ROBERSON, *Executive Director.*

CARNEGIE INSTITUTE OF TECHNOLOGY,
Pittsburgh, Pa., April 27, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Although I am late in doing so, I am replying to your letter of March 17, 1960, in which you kindly invite me—as a college president, I presume—to comment on specific statements in the Atomic Energy Commission's report to the Joint Committee on Atomic Energy, "The Future Role of AEC Laboratories."

As a member of the General Advisory Committee to the AEC, I had the opportunity, as a member of a subcommittee of the GAC, to discuss my views with the AEC staff from time to time while the report was being prepared. Although I might differ with the recommendations contained in the report in some details, I am in general agreement with the major and more important recommendations. The other members of the GAC had an opportunity to review the report. If my memory serves me correctly, the GAC as a whole expressed agreement with the major recommendations contained in the report.

Because of my special connection with the preparation of the report, I ask you to excuse me from commenting on the specific statements contained therein.

With kind regards,

Sincerely,

J. C. WARNER.

THE UNIVERSITY OF CHICAGO,
Chicago, Ill., May 6, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: It was thoughtful of you, on behalf of the Joint Committee on Atomic Energy, to send me a copy of the report entitled "The Future Role of the Atomic Energy Commission Laboratories." I greatly appreciate having the opportunity to comment on the report and, in particular, on its recommendations and a number of specific items you have noted. A few members of the university administration, in addition to myself, who are associated with the Atomic Energy Commission's programs for the most part through the Argonne National Laboratory, have reviewed the report with considerable interest.

As a general comment, I would like to take this opportunity to commend the Atomic Energy Commission, and especially those members of the Committee who were responsible for the preparation of the report, for the excellence of the task they have completed. In my opinion, this is the best description of the activities of the Atomic Energy Commission's laboratories that has ever been prepared. I am especially impressed by those sections that are concerned with the future role of the multiprogram laboratories, since it is in this area that the university naturally has its greatest interest.

The future role of the Commission's multiprogram laboratories is very well stated, indeed. These laboratories have provided the country with unusual strength in the field of atomic energy as a whole. The laboratories will become stronger within the next 10 years as their programs develop, particularly in the fields of the basic sciences, the development of nuclear power, and other peaceful applications of atomic energy. In order to maintain the strength of these laboratories, it is important that there be close cooperation with both the universities and industry. The report describes the policies for maintaining these relationships. We believe that in the Midwest the relationship between the Argonne National Laboratory and the universities has been enhanced during the past few years through the Association of the Midwest Universities, and that there are signs of increasing cooperation in programs of mutual interest. Cooperation between the laboratories and industry has always existed and should continue in the future at a more substantial pace. We believe it is important that when development programs have reached a certain stage—and here we are thinking primarily of the reactor program—they should be turned over to industry for further engineering and development, thereby providing the opportunity for the laboratories to devote a greater fraction of their efforts to advanced reactor concepts.

It is difficult to predict what changes will occur in the type of work and the level of effort in the Commission's research and development programs during the coming 10 years; however, we believe the report describes certain foreseeable trends that are bound to occur. Other programs will undoubtedly appear, depending upon the achievements of the next few years. The comments in the report on this subject appear to us to be well stated.

In any thriving research and development program it will be necessary to make changes in the facilities now available and to add new facilities. However, such changes will be dependent upon the demands of the Commission's overall program, within the limits of the availability of funds. Each multiprogram laboratory has personnel and facilities that in some instances are common to a number of laboratories and in other ways are unique. The development of any particular laboratory in the coming years will depend, to a large extent, upon the facilities and people presently engaged in productive work. It may well be necessary from time to time, for reasons of expediency, to eliminate some of the programs in the laboratories and to initiate others. It seems important to us, however, not to permit the multiprogram laboratories to become so large they are administratively unwieldy, and thereby incur the danger of becoming inefficient and ineffective in relation to the cost of operations. What this size should be in terms of the number of technical personnel is difficult to state. The size will vary from one laboratory to another and it will be determined largely upon the predominant type of activity in which the laboratory is engaged.

We feel that although it is important that greater emphasis be given to the support of basic pyhsics and biomedical research at the universities, nevertheless, these areas of research must be well-supported at the Commission's laboratories chiefly for two reasons: (1) So that there will be a knowledgeable group who can communicate with the universities, and (2) so that facilities be available at the laboratories that no single university today is financially able to support. A good example of the last-named item is the high-energy physics field in which very costly accelerators are needed if the country is to maintain its leadership in this field.

We agree with the report's recommendation to maintain the strength of the weapons laboratories by expanding nonweapons work at such laboratories if necessary. The Commission's multiprogram laboratories are an important national asset and should be maintained at the highest possible strength in keeping with their importance. In this regard it may be considered desirable in the future to carry out nonnucelar research in the Commission's laboratories if the occasion should arise. At the present time one can foresee worthwhile and demanding programs for a number of years in the nuclear field but with the rapid change in science and technology today it is not possible to predict what a few years hence will bring. In a few years nonnuclear research may be of greater importance than nuclear research for the overall national interest.

We feel that the program emphasis in the Commission's laboratories should be based upon the uniqueness of the laboratories and the ways in which they can best serve as cooperating units with the universities and with industry in keeping with the Commission's obligations (at a later time these obligations may be expanded into other areas outside of the atomic energy program). The laboratories should not compete directly with the universities but at the same time should have a well-informed and highly capable staff. Likewise, the laboratories should not compete with industry; on the contrary, the laboratories should aid industry rather than compete with it.

Again, I wish to thank you for the opportunity to present some of our thoughts relative to the excellent report to the Joint Commitee on Atomic Energy that has been prepared by the U.S. Atomic Energy Commission.

Very sincerely yours,

LAWRENCE A. KIMPTON.

UNIVERSITY OF IDAHO,
Moscow, Idaho, March 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Congress of the United States,
Joint Committee on Atomic Energy, Washington, D.C.:

I am in receipt of your recent communication concerning the future role of AEC laboratories.

I read with very great interest the report attached to your letter, and it appears to me that the planning has been very carefully delineated and I believe it is very worthy that we continue to do the work as outlined.

Sincerely,

D. R. THEOPHILUS, *President.*

UNIVERSITY OF ILLINOIS,
COLLEGE OF ENGINEERING,
Urbana, Ill., May 18, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: The copies of volumes I and II, "The Future Role of the AEC Laboratories," which were sent to President Henry, have been referred to me for comment.

I have read the report carefully and also have had it considered by other members of our staff, including representatives of the physics department and the engineering experiment station. We are generally in agreement with the planned program as outlined in the report. We feel that the greatest importance should be placed on the indication of an increasing support of basic physics and biomedical research at the universities rather than at Commission laboratories. If these policies are carried forward we feel that they will strengthen science and engineering in the United States in all areas. It is upon such general strength that any future progress of Commission objectives must be based. We look with favor upon increasing the cooperation between universities and Commission laboratories which has been evidenced particularly on the part of the Argonne which is the laboratory closest to us. We all expect that this cooperation will not merely be maintained but expanded.

May I quote in particular from the memorandum from Prof. G. M. Almy, acting head of the department of physics, which says:

"The universities, at the same time should urge the AEC and other Federal agencies to maintain and expand their support of research in the universities, particularly unprogramed research. The Federal agencies can do this in their own interest, for a number of reasons of which, it seems to me, the three most important are:

"(1) University scientists are more free to pursue the novel idea that may lead to really new discoveries than the Government laboratory with a heavy responsibility in programed research with definite goals.

"(2) The supply of young scientists for Government laboratories must come from the universities. If they are to be useful to the Government laboratories, they must be educated in fields of current interest, in many cases with modern equipment which is too expensive for universities to provide from their own budgets.

"(3) Support of research helps to establish good communication between Government and university scientists. In the case of a need, in an emergency, to expand the work of the Government laboratories, the university scientists are in a position to step into nationally needed programs without delay.

"From my reading of the report on the role of the AEC laboratories, the Atomic Energy Commission appears to be aware of the above arguments and does intend to continue to support university research in a substantial way."

Sincerely,

W. L. EVERITT, *Dean.*

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY,
Ames, Iowa, April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Washington. D.C.

DEAR MR. RAMEY: It was very kind of you to send me back in March a copy of the Joint Committee's report to industry, university and Government personnel concerning the future plans on atomic energy. I have looked these over quite carefully and I do not think that I have any specific suggestions to make. In the main, I think it is a very good plan. I must say, however, that the Atomic Energy Commission is probably in the same situation as are most of the

universities. Most of them have spent many hours on future plans, but as careful as they have been in preparing these plans, there are always times when changes must be made in them to meet the needs of the people and to keep abreast of new knowledge. I am sure this will be true with the Commission.

It was kind of you to send me this report, and in the main, I am in accord with it.

Sincerely yours,

JAMES H. HILTON, *President.*

UNIVERSITY OF MINNESOTA,
INSTITUTE OF TECHNOLOGY,
Minneapolis, April 20, 1960.

Mr. JAMES T. RAMEY,
Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Your letter of March 15 and the enclosed reports on "The Future Role of the Atomic Energy Commission Laboratories" has been sent to our department for comment. In reading the reports, I could not help but be impressed by the very important place these laboratories have assumed in our lives. Unfortunately this is a very complex and far-reaching subject. I am afraid that in the very limited time available it would not be possible to make constructive comments.

Sincerely yours,

ALFRED O. C. NIER, *Chairman.*

THE UNIVERSITY OF NEW MEXICO,
Albuquerue, April 21, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Volumes I and II of "The Future Role of the AEC Laboratories," published in February, were not only interesting but also very instructive. They provided an understanding of the missions and roles of the AEC laboratories.

I have consulted with H. L. Walker, our director of research and a former employee of AEC, on the subject of the AEC laboratories. I have no serious objections to the projected missions and roles of the AEC laboratories, and I am enclosing comments on the 11 items, as requested. I hope the comments will meet your requirements.

Sincerely yours,

TOM L. POPEJOY, *President.*

COMMENTS ON SPECIFIC ITEMS IN THE COMMISSION'S REPORT ON "THE FUTURE ROLE OF AEC LABORATORIES," BY TOM L. POPEJOY, PRESIDENT OF THE UNIVERSITY OF NEW MEXICO, AT THE REQUEST OF JAMES T. RAMEY

Item 1. The future role of Commission laboratories

We believe the AEC multiprogram laboratories have made great scientific contributions to knowledge and that further achievements may be expected in the future. We believe it is essential that the United States maintain research and development programs in nuclear weapons for the national security. We, therefore, concur that the multiprogram laboratories should be continued and maintained as vigorous institutions.

We believe that military projects in nuclear energy and nuclear warfare must be maintained for national security. The project engineering laboratories must, therefore, be maintained and continue to support specific military projects as primary missions.

If the United States is to remain strong and be a leader to the world in nuclear energy, it is imperative that nuclear materials continue to be developed and produced by the United States. The production plant laboratories should be maintained to develop new production processes and particularly those processes which may lower the unit cost of nuclear materials for the nuclear energy industry of the future.

The university laboratories are making great scientific contributions through basic research in the physical and life sciences. Because the universities have special qualifications and capabilities for the various projects, it is appropriate that there be university laboratories. The high costs incident to long-range and basic research involving the structure of the atom, subnuclear particles, and the effects of nuclear particles and ionizing radiations on living tissues are excessive to limited university financial resources. We, therefore, believe that the Commission should continue to support such long-range and basic research projects in university laboratories.

Item 2. Policies for Commission cooperation with universities

We believe the Commission's policy for cooperative use of laboratory facilities, doctoral and postdoctoral appointments, appointments of faculty to laboratory research staffs, summer training programs, and institutes for faculty is excellent. We believe these cooperative projects have strengthened our university faculties; they have also contributed to and strengthened the work and mission of the Commission. The policy should be continued and broadened to include additional activities where opportunities for interplay exist.

Item 3. Research and development objectives of the Commission laboratories

The objectives of the Commission, as stated in the report, are of the highest type and appear to be for the benefit of the Nation as a whole. We have no quarrel with these objectives, and we believe they are being avidly pursued by the Commission. We may mention, however, our interests in continued research for development and production of so-called cleaner nuclear weapons and breeder-type nuclear reactors for the production of electrical energy. We are pleased to note an increase in objectives and activities by the Division of Biology and Medicine in biological effects of radiation and radiation safety. We have personally come into contact with the Commission's programs and activities in education and training in nuclear science and engineering. This program has been of special significance to colleges and universities in training faculty and developing curriculums in nuclear science and engineering. We believe these programs should be continued into the future.

Item 4. Estimates of changes in work and level of effort in Commission laboratories

The estimates of level of effort for the next 10 years appear to be upward, almost without exception. Production process development appears to be leveling or even decreasing with attainment of production objectives. We concur that weapons development should remain at a high level of effort unless an effective disarmament program is achieved. Maritime, special purpose, and naval reactors are fairly new areas of effort which undoubtedly require additional research and development, and an increase in level of effort seems justified.

The civilian reactor program accounts for approximately 17 percent of the total R. & D. costs for 1960. Power reactor development is expensive, too expensive for industry to carry alone. There seems, however, to be considerable duplication of effort among the laboratories in reactor R. & D. but emphasis may be upon a single group of reactors at the individual laboratories. We believe reactor R. & D. is at an adequate level and that work on some concepts may be best completed before introducing new programs with increased R. & D. efforts. In the meantime, industry and private laboratories are becoming more knowledgeable in reactor design. This is perhaps one area where the Commission may support R. & D. in other than its own laboratories.

We would expect costs in physical science to increase during the next 10 years, especially in high energy physics, chemistry, metallurgy, and materials. Although the Commission contracts much of its physical science research to universities and industrial laboratories, future increase in efforts may, for the most part, be diminished rather than expanded in the national laboratories.

R. & D. costs in the biology and medicine program have doubled in the past 10 years, but the costs are only 7.5 percent of the total R. & D. costs for fiscal year 1960. We are pleased to see plans for an increased effort in biological effects of radiation and in radiation safety.

We have some doubts about the success of the program of international cooperation and assistance. Euratom does not appear to have succeeded in its mission. It has been our observation that some countries expecting assistance have no trained personnel, inadequate financing, nor real need for power reactors. We have some reservations on the advisability of any rapid rise in international co-

operation and assistance—at least until other countries can bear a more proportionate share of the costs.

Item 5. Future facility addition and replacement plans

We believe there is justification for a policy of replacement of temporary quarters with permanent buildings in the large multiprogram laboratories. We are somewhat apprehensive about facility additions which result in cumbersome and unwieldy complexes. Laboratories with 5,000 employees may result in a diminishing return on scientific productivity. We are inclined to believe that a personnel of 3,000 is maximum, and even this size may result in unwieldy problems of administration and communication. We are, however, conscious of the fact that the very great costs of plant and equipment dictate a concentration of manpower rather than an increase in numbers of facilities with limited missions and smaller numbers of personnel.

Item 6. Support of greater increases in basic physical and biomedical research at universities

We concur in the Commission's plans to support greater increases in basic physical and biomedical research. The universities have special capabilities for this type of research; and in addition, such projects have an educational value in training scientists and engineers. We are pleased to note that the Commission plans to increase the use of national laboratories for postdoctoral training in engineering and the sciences.

Item 7. Maintaining the strength of weapons laboratories

Continued research and development in nuclear weapons are essential to the national security. We concur in keeping these laboratories strong and vigorous. Not until there is an improvement in the international peace situation or an effective disarmament program, however, would we concur in a policy of expanding nonweapon R. & D. in the weapons laboratories. We believe it is essential to keep their engineering and scientific staffs intact for the next decade.

We were pleased with statements by the Commission that "make work" will not be resorted to, that the laboratories will not be turned into "job shops," and that there is a realization that too large facilities and personnel may result in diminishing reurns on scientific productivity.

Item 8(a). Planned changes in staff and program emphasis

Brookhaven National Laboratory in Long Island and Lawrence Radiation Laboratory in Berkeley are the two laboratories for which the Commission contemplates major increases in staff. Both of these laboratories are heavily committed to educational programs through association with educational institutions, which is excellent. We have no criticisms of planned changes in staff and program emphasis in these two laboratories.

Item 8(b). Maintenance of present number of scientists

We are of the opinion that too great a concentration of personnel in one facility may result in diminishing returns on scientific productivity, but we are not offering suggestions as to number of personnel for maximum efficiency. We note, however, that for the 1951–60 period AEC R. & D. costs increased by a factor of 5.67 while completed plant and equipment costs increased by a factor of 4.81. During the same period scientific and engineering personnel increased by a factor of 2.4.

Item 8(c). More advanced nuclear research and development

We believe greater emphasis should be given to more advanced nuclear research as additional basic and fundamental information becomes available, and there is also a need for more advanced and complex experimental work.

Item 8(d). Work in nonnuclear research

If the Atomic Energy Act of 1954 does not prevent the Commission from participating in nonnuclear research, we know of no reason why such a policy should be adopted. The Commission is not an action agency of the Federal Government in terms of actually performing research and development. The Commission supports research and development with Federal funds through contracts with industry and universities, and all the national laboratories are operated under contract. The National Science Foundation also supports research with Federal funds, but the mechanism is through grants-in-aid rather than contracts. We would not, however, condone extensive overlapping of the missions of the NSF and the AEC.

UNIVERSITY OF NOTRE DAME,
Notre Dame, Ind., March 30, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Here are my comments on the January 1960 AEC report to the Joint Committee on Atomic Energy, following the specific items as enumerated in your letter.

1. The future role of Commission laboratories

On page 7 of the report, the numbered paragraph 2 has the Commission saying to the Joint Committee that "the maintenance of a sustained effort in nuclear weapon technology is essential to the Nation." One can hardly quarrel with this statement if it is intended to report the Commission's current interpretation of its legal and executive responsibility. The question of a continuing sustained effort in nuclear weapons technology is, however, also a political issue depending upon the Nation's international posture. It is quite conceivable that at some time in the future nuclear weapons may not be as essential to the Nation's security as they are today. This determination would, of course, have to be made by responsible officials outside of the Commission, even though AEC would have to be relied upon for the advice and technical data in support of such a decision were it ever made. Perhaps the policy implicit in the quoted statement should, therefore, be conditioned by such a word as "presently" essential to the Nation.

2. Policies for Commission cooperation with universities and industry

This is my most important comment. The report states that the AEC intends to expand its reliance upon university laboratories for research directed toward accomplishment of AEC missions. If university participation increases, the difficulty created by the current practice of incomplete cost reimbursement is accentuated. Under the current practice, universities are expected voluntarily to offer to contribute to each AEC-sponsored research program. Currently at Notre Dame, our research contribution ranges from 50 percent down to 11 percent of estimated yearly project costs. Among AEC research contract administrators there seems to be a general tendency to negotiate the university's contribution upward. At the same time, university research administrators continually try to negotiate university's contribution downward.

The criterion applied by AEC appears to be the degree of relevance of a particular project to the Agency's mission. AEC requests to the university to engage in particular research are usually accompanied by agreement to a relatively low university contribution. On the other hand, if the research proposal is initiated by the university, the AEC takes the view that the university's contribution should be greater. This procedure is arbitrary and in many instances unfair. It is quite conceivable that a reasearch proposal initiated by the university could have much more relevance to the AEC's mission than work requested by the Agency. This is a question of relative competency to visualize important new research that should be undertaken. Also, the university researcher is put under pressure by AEC staff for a higher university contribution with the implication that approval of the research hinges upon such agreement. I believe this approach to funding places an undue burden both on agency staff and upon university personnel. It creates friction between university administrators and their faculty. The Atomic Energy Commission should return to policy of full reimbursement of costs on all research contracts with universities, thereby establishing a uniform rule not subject to negotiation between agency professional staff and university faculty. Neither the university faculty nor the AEC professional staff has the time or the extra emotional resources to get involved in these budgetary negotiations.

The Federal Government and the AEC should realize that even without the contributions now required by law, the university's contribution to the AEC program is a major one. The university dedicates to nuclear research major facilities, competent faculty, and promising students—all involving outlays of money and effort not compensated for in research contracts, even where a full overhead rate is allowed. Finally, the AEC has a responsibility to insure the continuing financial integrity of the very institutions it says it will continue to rely upon more heavily in the future. To shift the Federal burden for research in the national interest to students, alumni, and benefactors of a private university not only forces compromise in the other educational objectives of the

university, but also tends to defeat the public interest in improving higher education.

The policy of this whole matter of university overhead has recently been reasonably stated by both the President's Scientific Advisory Committee and the National Science Board. The above critique is in keeping with the conclusion reached by both of these bodies. I am a member of the National Science Board.

3. Research and development objectives of the Commission laboratories

The Commission laboratories play a most important role in the development of atomic energy. They constitute an effective complex with experienced and competent personnel for the solution of problems that certainly cannot be approached through any other instrumentalities available to our Nation. The programs of these laboratories as described in the report seem well designed to serve the national interest. It may not be too great a sacrifice to the progress of the nuclear development program, however, to avoid pursuing those peaceful applications which require testing and development so closely associated with weapons as to compromise our good faith in arriving at a nuclear disarmament agreement. Specifically, our choice between nuclear means to create harbors or to move mountains and an effectively inspected and controlled nuclear disarmament program certainly must be in favor of the latter.

5. Future facility addition and replacement plans at Commission laboratories

The Commission's plans seem to provide for a reasonably controlled growth responsive to the obvious future expansion of nuclear technology. While people more expert in the field may have some criticism of specific growth projections, nevertheless nuclear technology is yet in its ascending growth cycle requiring at least the expansion of effort planned by the Commission.

6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories

Already aware of the tremendous contribution that AEC supported research has made to the universities, the planned increase in basic physics and biomedical research will undoubtedly be most welcome to the universities and should result in effective advancement of knowledge in nuclear science. Our only reservation is expressed under paragraph 2 above.

7. Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary

The success of basic research is peculiarly dependent upon continuity and stability. Certainly in nuclear science some of the most vital of this research is being conducted in the weapons laboratories. It makes great sense to keep these reservoirs of capability for nonweapons work completely filled and effectively occupied. Certainly there may be compelling national defense reasons also for keeping these weapons research teams substantially intact until a final and irrevocable nuclear disarmament position is reached. Recent developments in nuclear research would seem to indicate that the dividing line between weapon and nonweapon work may be extremely difficult to discern and some very valuable advances lost if some things characterized as weapons are discontinued. Of course, this will take very judicious technical evaluation.

8(a). Planned changes in staff and program emphasis at each of the Commission laboratories

8(b). Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity

The AEC has traditionally administered its laboratory programs with considerable flexibility subject to constant internal reevaluation. As a member of the Argonne Policy Advisory Board, and on the assumption that my experience there is typical of the administration of the other Commission laboratories, I am convinced that the AEC has worked out a suitable program involving both staff levels and concentration of effort. There will be problems, but with good scientific advice and efficient administration, the problems can be solved.

8(c). Whether greater emphasis should be given to more advanced nuclear research and development projects

There may be room for more effective organization to insure that the most advanced theories, ideas, conceptions, and intuitions involving nuclear research

are given timely and intelligent evaluation and, if warranted, vigorously pursued at the basic research level. The organizational structure of AEC is such that preoccupation of the staff with routines could very well impede imaginative and original research by scientists, both inside and outside of the organization. A board of qualified scientists freed of administrative responsibilities should be available to the Commission for planning and evaluation of research. This should be an elite, full-time, single-purposed, highly compensated group with complete access to all scientific information on atomic energy whatever its source.

8(d). Whether work in fields of nonnuclear research would also be performed which would utilize the scientific personnel and facilities at Commission laboratories

On principle, I do not think that the AEC should be encouraged to engage in nonnuclear research merely to utilize scientific personnel and facilities it may have at hand. It would seem to be a mistake to broaden the concept of AEC's mission to make it a general basic research organization. If the personnel and facilities at hand cannot be productively used in nuclear-related research, then certainly the personnel should be encouraged to contribute to other organizations, and the facilities either decommissioned or turned over to other organizations with appropriate research missions.

With every best wish, I am,

Sincerely yours,

REV. THEODORE M. HESBURGH, C.S.C.,
President.

UNIVERSITY OF PENNSYLVANIA,
Philadelphia, April 7, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: It is a pleasure to endeavor to respond to your inquiry of March 16 in which you enclosed the document entitled "The Future Role of the Atomic Energy Commission Laboratories." I have solicited some advice from a few of my professional colleagues and am glad to give you the following thoughts.

In general I believe that the Atomic Energy Commission's laboratories have played an important and constructive role in scientific development during the past decade. The policy of the Commission and its laboratories has been less enlightened in general than the policies evolved by the Office of Naval Research, but difficulties in security matters may account in large part for this fact. Laboratories of the type of the AEC, in common with industrial laboratories, tend to suffer in enterprise and imagination from the lack of flow of students from them which is enjoyed by educational laboratories.

My most intimate acquaintance is with the Brookhaven National Laboratory which, while it has not fulfilled all of the hopes which the associated universities had for it, has done an excellent job within its limitations and has contributed very significantly to knowledge and to skilled personnel.

Collaborative work between the Commission and university laboratories has appeared to me to center somewhat unduly in a small number of university laboratories, and this, I think, tends somewhat to restrict the variety of talented ability which could come to the service of the Commission's program.

In closing I would like to quote three paragraphs from the statements of some gentlemen of our scientific faculties which are well stated and carry my concurrence:

"There seem to me to be two points worth making, one having to do with the content of the program and the other with the way in which the program is carried out. The AEC's interest in basic research is at least partially based on specific needs. They have quite correctly assumed that their national laboratories will be better able to carry on their applied functions if the laboratories have undirected basic research programs as well. Their need for specific knowledge as a byproduct of research is reflected in the great emphasis they place in their ability to channel research moneys in definite areas. This, it seems to me, would be quite fine if the AEC were not the sole source of support of many areas of physics today. An extreme example of the point I am trying to make is the

statement in the report that the AEC is the sole Government support of the studies of the genetic effects of radiation. It seems to me quite obvious that the AEC should be engaged in these studies, and it is also obvious to me that in an area in which it has such a large stake it should not be the sole source.

"The second point I would like to make concerns the relationship of the universities to the national laboratories. Although the report emphasizes the existence of university collaboration and graduate student training, the effort is lamentably small in relation to the traditional role played by the university in all areas of research in the past. I can mention two strong examples emphasizing the point I am trying to make. The one is Brookhaven National Laboratory, which started out, in concept at least, to fulfill just the role of helping universities play their traditional role in research in an area which has become so costly. That role has been relegated to one of minor significance in the operation of Brookhaven. A second example to point is the battle being waged by MURA in which the central issue is the role of the universities in the national laboratory setup.

"No overall picture of the personnel needs necessitated by the expansions outlined are presented. It would seem that the Ph. D. education of the needed scientists may be one of the critical areas of the next decade. If this is the case, then one of the important aspects will be the strengthening of the universities in Ph. D. type research facilities. It seems inevitable that the costs per Ph. D. produced in high energy physics will remain high. The national laboratories will primarily supply post doctoral training as indicated on page 69. Therefore, it would seem advantageous to invest a lot more in low and medium energy nuclear physics facilities and operation both for the educational aspects of the research and for the continued interest in such research for basic knowledge." (See p. 47 also.)

Trusting that these brief comments will be of use to you, I am,

Very sincerely,

GAYLORD P. HARNWELL.

PURDUE UNIVERSITY,
ENGINEERING EXPERIMENT STATION,
Lafayette, Ind., April 29, 1960.

Comments on the Commission's report on the future role of AEC laboratories.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Your letter to Dr. Chenea of March 15, 1960, has been referred to me in my new position as head of the Department of Nuclear Engineering and associate director of the Engineering Experiment Station at Purdue University. Accordingly, I am happy to offer to the Joint Committee my comments on the report on the future role of the AEC laboratories.

It is clear that the AEC laboratories have performed well in terms of the missions for which they were created. With advancing technology, with increasing need for nuclear research and development, and with rising costs for experimental equipment, these laboratories have come to be large and important segments of the scientific and engineering community. They have, and will continue to have, an important role to play in carrying out AEC responsibilities for advancing nuclear technology.

As these laboratories grow, they become better known, they acquire a larger variety of assets, and people acquire more confidence in them, with the result that there is a tendency to give more and more work to them. There can be no doubt that rapid expansion of research and development activity is in the national interest, but it is essential that this expansion occur wherever the capability exists throughout the Nation, and that we not fall into the easy habit of giving more and more problems to large laboratories simply because of the bigness and reputation which they have already acquired. The roots of our scientific and engineering progress must be widely distributed among all of the places where scientific and engineering talent is to be found in our universities, research institutes, industrial laboratories, and other Government laboratories as well as in the AEC laboratories. Putting it differently, there is a danger that bigness in itself may produce such rapid growth of these AEC laboratories that the realization of the potential of smaller, and less well known, and less well established research institutions may be inhibited.

This applies to all kinds of lesser laboratories, including on the one hand the industrial laboratories, which are usually concerned primarily with development and with applied science, and, on the other hand, the university laboratories, where the pursuit of knowledge is more often for its own sake. There are large sources of talent in this wide spectrum of laboratories which are invaluable to the Nation and with which no single laboratory can ever compare in overall competence and ingenuity for the discovery and study of new ideas. Furthermore, the university laboratories in particular, in the process of carrying out research, are at the same time replenishing and expanding our reservoir of scientific and engineering talent on which the total research and development program of the Nation depends.

It is, therefore, of the utmost importance that the AEC use the best possible judgment in allocating its research and development funds between the AEC laboratories and all other laboratories having corresponding capabilities. The manner in which the AEC administers these funds will have an important bearing upon the research capability of our country a decade from now. To enhance this overall capability of the Nation to the utmost must be one of the major objectives of the administration of these funds.

The policies as set forth on pages 9 to 12 cited in your item 2, relating to cooperation with universities and industry, make it clear that the AEC recognizes this important objective, and these policies are excellent as stated. The real question, however, is how successful the AEC will be in carrying them out.

The substance of the statements referred to in each of the other seven items is also quite acceptable, but in relation to items 7 and 8, for example, relating generally to laboratory growth, the problem lies not so much in numerical measures of the growth of these laboratories as in their position in relation to the total national picture. The question is not so much whether the laboratories are growing at the right rate, as it is whether the total research and development capability of the country is growing as rapidly as possible with the laboratories in proper balance with the total.

This matter is of such importance that it may be well to inquire further as to how the policies stated on pages 9 to 12 are to be implemented and administered. It is desirable that the AEC be so organized from an administrative standpoint as to be sure that full attention is being given not only to programing for the carrying out of these policies but also for constantly measuring the success with which they are being carried out.

Very sincerely yours,

PHILIP N. POWERS,
Associate Director, Engineering Experiment Station.

RENSSELAER POLYTECHNIC INSTITUTE,
Troy, N.Y., April 19, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Washington, D.C.

DEAR MR. RAMEY: I would like to offer some thoughts on the Atomic Energy Commission's report of the future role of AEC laboratories, in answer to your invitation. The Joint Committee and the AEC are to be congratulated for encouraging analysis of this important subject.

The report states, with good reason, that Government-owned installations will continue to have an important function that complements the functions of universities and of industry. However, the proper balance in terms of tax dollars between the three is not easy to establish, since they overlap to some degree. This makes it all the more important to analyze the virtues and limitations of the three in terms of trends and of the future.

It requires difficult and unusual statesmanship to establish a Government operation which meets an emergency of the moment and then gracefully retires or blends into the normal life of the Nation. At this moment of atomic energy history, when university and industry participation are still badly handicapped and inadequate, the temptation is strong to get jobs done by the easy device of assigning dollars and functions to Government laboratories. But this easier path may only delay progress in our technology and general economy. To depend on these laboratories as primary source of progress in atomic development, rather than on the incomparably vaster potential resources of the Nation's universities and industries, savors of a Maginot Line philosophy. I am

confident that the AEC does not subscribe to this limited view, but the mood and words of the report do not assure that in time tax dollars will be largely spent to seek this incomparably greater stature for atomic energy in the Nation.

What does atomic energy most need over the next two decades? It needs hard work and experience with reactors and fusion experiments now underway. But more than that it needs—

(*a*) An accelerated rate for producing ideas and "breakthrough" in technology of the types that have made our industries preeminent;

(*b*) Accelerated progress in basic research; and

(*c*) It needs to be much more completely accepted and integrated into the normal educational and industrial and economic life of the Nation. Moreover we can expect that it will require much effort on the part of the AEC to take atomic energy out of the artificial setting created for it by the hot and cold wars, and to bring about this integration.

During war emergency new ideas can spring from many directions, but in normal times they are generated from more conventional motives. The profit motive and competition are still the most powerful forces in the world's commercial and industrial markets to generate new equipment, new materials, new designs, and marketable ideas. State-directed economies, whether in the United States or the U.S.S.R., have been much less successful in such activities. Government-owned installations can offer nothing as steady diet that compares with the stimulus of the profit motive for the long peacetime pull for such ideas.

The AEC supports many research programs at universities. Studies have indicated clearly that basic research thrives best in universities. This is true in part because professors teach basic concepts and because they have more freedom to delve into unexplored territories. On the other hand, most college professors could become as institutionalized and pedestrian in their thinking as can people in national laboratories and in industry were it not for the stimulating influence of their better students who are out to build careers. The presence of such students, and their willingness and freedom to explore new directions, probably accounts for most basic ideas of the world.

When considering the role of Government-owned installations one must assess the nature of the inner forces and basic motives that can be depended on to maintain productivity at each site. National laboratories can be created to meet a challenge, but like any other human organization each runs the risk of settling down to routine institutional "club" life if there is no natural inner drive; and operations have a way of continuing long after the original objectives have been accomplished.

With these inner forces and motives in mind, it would seem that any activity that can be designed to attract the competitive resources of industrial groups, had better be left out of national laboratories.

Similarly, basic and some applied research are best left with universities, where there is the additional advantage that this research is desperately needed to produce better prepared scientists and engineers on whom our future depends.

In this connection one must be careful not to confuse separated Government-owned and Government-directed operations, such as Oak Ridge or Argonne or KAPL or Hanford, or Princeton's Forrestal Research Center as in any sense enjoying the virtues of industrial competition or university function.

One special situation has to do with large research accelerators and reactors such as have been built at Brookhaven. Their future value is likely to be proportional to the number of young graduate and postdoctoral students and visiting scientists that make use of these facilities. It is the policy and practice at Brookhaven to promote such use with respect to a number of its operations. Probably each large research operation at national laboratories should be evaluated in these terms.

There is need to look suspiciously on any large research operation that does not have associated with it comparable numbers of students at doctoral level, or of visiting scientists. While it is not difficult to find exceptions to this generality, I would nevertheless be troubled by the Argonne claim that half of its huge research effort is basic research, if basic research is what the AEC expects of Argonne.

As another example, the thermonuclear program is now pretty much confined to several groups of highly able teams. But the whole area is new and requires many basic ideas that may or may not originate with teams that are busy designing and operating hardware. Yet it seems to be the general practice of the AEC (although apparently not policy at the higher levels) to avoid

sponsoring participation on the part of universities that want to undertake small research programs related to this broad field. The schools must participate in such activities if they are to turn out better prepared scientists and engineers. The situation can be serious if it persists, because under normal circumstances most basic ideas on plasmas and electrodynamic phenomena would be expected to come from doctoral graduates of the next two decades from many schools. There is too much chance that successful "thermonuclear" ideas may not originate at these large-hardware laboratories at all. But as it stands, the number of doctoral students who have contact with Project Sherwood, or related activities, is pitifully small and out of proportion to the dollars spent, even though two of these operations are supposedly university directed.

Very truly yours,

V. L. PARSEGIAN,
Dean, School of Engineering.

APPENDIX V

COMMENTS RECEIVED FROM AEC LABORATORIES

GENERAL ELECTRIC CO.,
AIRCRAFT NUCLEAR PROPULSION DEPARTMENT,
Cincinnati, Ohio, April 26, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I appreciate very much the opportunity offered by you to comment on the Atomic Energy Commission's report on the "Future Roles of Atomic Energy Commission Laboratories." The two volumes represent a thorough and carefully detailed review of a difficult problem.

The following represent my views with respect to the specific items on which you requested comments. In general, my comments are limited to their application to the General Electric Aircraft Nuclear Propulsion Department's activities.

1. The future role of Commission laboratories by class

In accordance with the report, our activities would be considered as those of a project engineering laboratory, and I would concur with the basic objectives stated.

2. Policies for Commission cooperation with universities and industry

In general, I would agree with the stated policies. The real point is the way and the degree to which the policy is implemented in practice. I believe that it is desirable to provide in this country a strong, competent, and economically sound atomic energy industry. To help insure this will require conscientious and distinct effort not only to achieve an orderly progression of activities from Commission laboratories to industry, but a conscious effort to place in the Commission laboratories initially only those activities which are indeed best accomplished in this fashion.

3. Research and development objectives of the Commission laboratories

The objectives as stated for the aircraft nuclear propulsion program are essentially as we see them.

4. Estimates of changes in work and level of effort in Commission research and development programs

The projected levels of effort stated for the direct cycle activities would appear to us to be consistent with the needs, with the understanding that an increase will be required with preflight and flight test programs.

5. Future facility addition and replacement plans at Commission laboratories

No comment.

6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories

No comment.

7. Commission's intent to consider maintaining the strength of weapon laboratories by expending nonweapons work at such laboratories if necessary

No comment.

8. (a) Planned changes in staff and program emphasis at each of the Commission laboratories

We are in general concurrence with the statements concerning our activities.

(*b*) *Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity*

In our case, we continually evaluate our needs for the most effective progress in achieving desired results and believe that by this process a balance in the number of scientific and technical professional personnel and in total number of personnel is maintained.

(*c*) *Whether greater emphasis should be given to more advanced nuclear research and development projects*

No comment.

(*d*) *Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories*

In general, it may be expected that research in the nuclear field will make valuable contributions in nonnuclear fields. I would believe that most effective results would be achieved by maintaining complete emphasis, at all times, on the nuclear needs.

Again, let me say that I appreciate the opportunity to comment on the report and I hope that you and the Joint Committee on Atomic Energy will find our comments to be useful.

Sincerely yours,

S. J. LEVINE, *Acting General Manager.*

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY,
Ames, Iowa, April 28, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I have examined the report which you sent me on "The Future Role of the AEC Laboratories," and I believe it is an excellent report. I believe the authors have investigated this subject thoroughly and I am in agreement with their conclusions in almost all aspects.

In reply to your specific questions:

1. The future role of Commission laboratories by class (pp. 6–9, vol. I)

I believe the authors have amply demonstrated that all the types of laboratories are essential to our national safety and welfare, and that the multiple-purpose laboratories have been particularly successful in bringing together and coordinating research in the many fields of science which are needed if this country is to maintain a lead in the atomic energy field.

2. Policies for Commission cooperation with universities (pp. 9–17, vol. I)

I also believe that it is essential that the AEC maintain a strong university program. The future scientists which we badly need are trained in the universities and we need the best men obtainable for the scientific staffs of these universities. A very important consideration as to whether a topflight scientist remains with the university is whether he has facilities to carry out the type of research in which he is vitally interested. Therefore, support of these men within the universities supplies them with the equipment they need, and the Government benefits by having the basic science advanced in the fields where these men are experts.

3. Research and development objectives of the Commission laboratories (pp. 13–26, vol. I)

The delays encountered in virtually every new scientific program are traceable to the lack of availability of materials capable of withstanding the conditions that must be met. The importance of good research and development programs in metallurgy, ceramics, solid-state physics, etc. cannot be overemphasized. A proper balance must be maintained between fundamental research and work on applied programs. It is also very important that the frontiers of our basic understanding of scientific fields be advanced in certain areas and the Commission laboratory is the ideal place to organize a concerted, coordinated program in these areas. The country cannot afford to wait until these areas are developed by chance.

4. Estimates of changes in work and level of effort in Commission research and development programs (pp. 27–63,-vol. I)

The estimates of changes appear realistic although the amount of confidence that can be placed in long-range estimates is small. The growth of several of the AEC's present programs could not be foreseen only a few years ago. New advances in several areas of science could have a profound effect on the most economical nuclear reactors of the future.

It should be emphasized that if the Commission laboratories are to be maintained at any given manpower level, this does not mean the present dollar level. The scarcity of scientists means that each year it costs more to maintain a scientist. As the sciences advance, the equipment becomes more expensive and there is a steady increase in the cost of materials. In addition, the more reports and controls which the Government requests means that nonacademic personnel have to be employed to furnish these checks, so the future cost of any laboratory will depend on the amount of these services requested.

5. Future facility addition and replacement plans at Commission laboratories

It is very important that the Commission laboratories be equipped with the best scientific equipment obtainable. Adequate funds for providing this equipment and keeping the facilities in a condition of maximum utility must be appropriated annually. Stop-and-go or feast-or-famine support can seriously disrupt progress in this vital field.

The major cost of operating most Commission research laboratories is salaries, and with the scarcity of scientists it is important that the talents of these men be utilized to the maximum extent. The present national policy of arbitrarily fixing a dollar limitation on equipment and general plant projects (repairs and renovations) is very disruptive of planned, efficient laboratory management. These funds should be part of the general operating costs and the decision as to whether money should be spent for equipment or people should be left to the discretion of the director of the laboratory under his total allocation.

6. Plans to continue the support of greater increase in basic physics and biomedical research at universities rather than at Commission laboratories (p. 66, vol. I)

The report refers to basic physical research rather than basic physics. It would not be wise to reduce the amount of basic physical research done in the Commission laboratories. This type of research must be systematically coordinated if that area of science is to advance at the maximum rate, and experts in these fields are needed in the laboratories if the other responsibilities of the laboratories are to be accomplished.

In order to provide the necessary fundamental information for applied programs of the future, the level of this type of research in both the facilities of the universities and the Commission laboratories should be expanded.

7. Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary (p. 67, vol. I)

The general policy has much merit but any specific decision would have to be decided upon taking into account the scientific and political atmosphere prevailing at the time.

8. (a) Planned changes in staff and program emphasis at each of the Commission laboratories (vol. I, pt. II, starting on p. 71)

The plans seem adequate at the present time.

(b) Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity

The levels indicated seem adequate but may prove to be conservative as research becomes more complex requiring additional specialists such as computer experts, mathematical analysts, etc.

(c) Whether greater emphasis should be given to more advanced nuclear research and development projects

There is the danger of complacency. A balance must be struck between supporting bold new ideas and going on with tried-and-true designs.

(d) *Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories*

The nature of science is such that one cannot really pinpoint whether some projects are "nonnuclear research" or not. The research at the Commission laboratories should be broad enough so that a liberal interpretation of "nuclear research" can be made. Too restrictive an interpretation would impede progress in nuclear research of all kinds. When a Commission laboratory is particularly qualified both in staff and equipment to solve some pressing problems of national defense, other than that related to nuclear energy, and the laboratory is interested in doing so, I believe it should be encouraged. However, when the objectives of the research are distinctly different than those ordinarily carried on by the laboratory, I believe it would be wiser to establish new laboratories for this purpose.

Sincerely yours,

F. H. SPEDDING, *Director.*

ARGONNE NATIONAL LABORATORY,
Argonne, Ill., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you for sending me the copy of the Commission's report on "the Future Role of the Atomic Energy Commission Laboratories," and for giving me the opportunity to present my comments.

First, I should like to express my congratulations to the Atomic Energy Commission, and particularly to its ad hoc committee which prepared this report, on the fine job that has been done. Having prepared a similar report recently covering the 10-year outlook for Argonne National Laboratory alone, makes me realize the tremendous magnitude of the task faced by the committee and how excellently it has discharged its assignment.

We, at Argonne National Laboratory, believe that the report states effectively the general philosophy of operation which the Laboratory has attempted to follow over the years. It is a real satisfaction, however, to have this philosophy explicitly stated. The Laboratory can plan for the future much more effectively in view of this explicit statement than has been possible heretofore. We trust that the Joint Committee will agree that this report does present an agreed upon philosophy of operation and a long-range program which can serve as a continuing guide for the laboratories' operations in the future.

Since the tempo of change in our present day world is so rapid, it should be recognized that any charter for the laboratories can represent no more than a statement of the current responsibilities assigned to them and the corresponding requirements of the organization involved for discharging those responsibilities. This report, excellent as it is, should not be considered immortal—it should be reviewed for continuing adequacy from time to time.

In reply to your question No. 1, "The future role of the Commission laboratories by class," I believe the entire section is well stated. Certainly with respect to the multiprogram laboratories, I believe the statement is excellent.

Question No. 2. "Policies for Commission cooperation with universities and industry." Again, I believe the report outlines a fair and workable program. In the particular case of Argonne National Laboratory, I would like to stress that our relationships with the universities, and in particular with the Associated Midwest Universities, are steadily developing and are beginning to materialize in mutual programs for cooperation in which the Laboratory is playing a significant role in support of midwest educational programs that could not readily be instituted without its collaboration. On the other hand, this same collaboration continually strengthens the Laboratory in its own activities. We foresee that this activity of the Laboratory will increase significantly in relative magnitude within the scope of the Laboratory's activities and become of ever-increasing importance to the national education program over the coming decades.

Question No. 3. I believe this statement with respect to research and development objectives of the Commission laboratories is well presented. Again expressing the viewpoint of Argonne National Laboratory, I would like to stress the importance of the area of applied science research and of general development studies as being of particular importance in the activities of the multi-

program laboratories. The case for basic research has been made in many arenas and cannot be overstressed. The case for research in applied science is also strong; it should be considered a major objective on its own for its own values and not subordinated as an adjunct to specific projects. This field is of additional importance at Argonne National Laboratory in that it provides one of the most vital areas for intensive cooperation with the many strong engineering schools of the Associated Midwest Universities. The major problem is that of guaranteeing adequate financial support for a major effort in a field whose intrinsic values have not yet been generally recognized as important in themselves.

Question No. 4. In response to your request for comments on "Estimates of changes in work and level of effort in Commission research and development programs," I am not competent to speak for all of the areas, since the Laboratory is not presently concerned in an appreciable number of the programs discussed. In those areas in which we have an active part, the programs all appear extremely reasonable and proper.

The comments on page 40 with respect to the nuclear technology programs are directly germane to my remarks under question 3, but perhaps should be mentioned again. I believe that the description of nuclear technology as presented is valid for the years immediately ahead, but I am convinced that the area should broaden in the very near future to the consideration of applied research problems on a basis broader than that specifically and directly tied to nuclear reactors.

Question No. 5. In commenting on the sections on "Future facility addition and replacement plans at Commission laboratories," a laboratory director is, I fear, much like a general or admiral in that there is always a tendency to believe that one never has either enough men or sufficient supplies to discharge the responsibilities placed upon him. In general, I definitely agree with the Commission's statement. I question somewhat the control of laboratory size in terms of total employees, since different laboratories are organized in different manners. For example, at Argonne National Laboratory, the Laboratory itself is completely responsible for all of its ancillary operating activities, while at some of the other laboratories various supporting services are supplied by organizations whose personnel are not employees of the laboratory proper and consequently do not appear as laboratory employees. Such differences tend to make comparability on a gross personnel basis somewhat difficult. However, even in the case of our own Laboratory, I agree that the 5,000 level is not too far from an optimum, though we may find definite curtailment of some activities which logically would fall within our multiprogram complex were this figure to be interpreted as an inviolate and unalterable ceiling. It must be remembered that the management problems associated with size are a function of the character of program as well as of numbers of people involved.

The statement with respect to facilities I believe is also, in general, valid. The Laboratory has one or two projects which are in various stages of Commission consideration which might fall outside of a literal interpretation of this section, but these are items which have been under mutual consideration for some period of time and I believe fall within the general spirit of this statement. With respect to experimental facilities, of course, the requirements will continue to develop as long as the existence of the laboratories is justified at all. In a laboratory the product is ideas. The only instrument which can produce a new idea is the human mind, so that the production facilities of the Laboratory are in truth the brains of its scientific and technical staff. In a real sense, the equipment and the experimental facilities are the raw materials which the human mind uses to create new ideas and to test their validity. In many instances, therefore, new equipment and new experimental facilities are used up rapidly insofar as their effectiveness in promoting new ideas is concerned. This is not to say that their usefulness is totally at an end when they have become obsolete as far as their "frontier use" is concerned, for in many cases they can continue to supply useful fill-in data over periods of many years. It is true, however, that as far as maintaining a position of leadership is concerned, obsolescence of equipment and experimental facilities is very rapid. In consequence of this fact, as noted in the report, a continuing requirement for new experimental equipment and new facilities is a concomitant of creative and worthwhile laboratories and of national leadership in the field.

Question No. 6. The statement on "Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories" is, I believe, sound. In order to assure the continuing

close interchange between universities and these laboratories, which is important for the maximum output of both, care must be taken to assure that closely related activities are carried on in both the laboratories and universities. While large programs in a given field of interest which can be carried on in universities need not receive major support within the laboratories, some support must be provided to maintain the community of interest between them.

Question No. 7. The statement on the "Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary" is simple commonsense. Speaking for myself, as a citizen and as a scientist, I am 100 percent in agreement that, in the national interest, Los Alamos, Livermore, and Sandia must be maintained as strong and vigorous institutions.

Question No. 8. (*a*) "Planned changes in staff and program emphasis at each of the Commission laboratories." The comments here apply only to Argonne National Laboratory. The statement with respect to the program at Argonne National Laboratory and the probable changes in program emphasis reflect, in general, the conclusions of the Laboratory's own report on its long-range program. Differences are mainly in matters of detail which are always subject to change—the general outline is certainly satisfactory. Clearly, this is a statement as of 1959–60. What effects new discoveries in almost any of the fields of interest at the Laboratory might have on the overall program emphasis cannot be foreseen, although they might be very significant. While the report makes this clear, it should be emphasized once again. I believe the statement given for Argonne National Laboratory is as sound as any statement could be today. As was necessary, the report is so concise that it can serve only as a basic guide for program planning.

(*b*) "Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity." As stated earlier, I am in general agreement with the Commission's expressed policy as to the size of the laboratories. In our own forecasts of the personnel required to implement the program as presented beginning on page 79, we find that a strict interpretation of the 5,000 limit could lead to some difficulties. However, under any circumstances, the discrepancies do not appear to be large. We believe that our program responsibilities, as we understand them, can be met within this general size range. It should be emphasized that in a laboratory, it is quality of staff that really counts, not numbers, and the efforts of the Laboratory have always centered on increasing the quality of its staff first and foremost, and in increasing its numbers only when the need for additional help to meet program objectives was clearly essential. The Laboratory proposes to continue this basic philosophy and to place ever increasing emphasis on upgrading the quality of its scientific and technical personnel.

(*c*) "Whether greater emphasis should be given to more advanced nuclear research and development projects." Inherent in the program for Argonne National Laboratory as presented, is the commitment that the Laboratory should place greater and greater emphasis on more advanced nuclear research and development projects as rapidly as it can discharge present responsibilities. We agree with this point of view and will endeavor to the best of our ability to make the shift as rapidly as possible.

(*d*) "Whether work in fields of nonnuclear research should also be performed which would utilize the scientific and technical personnel at Commission laboratories." Such work should certainly be possible. At the present time, the staff are fully occupied with activities directly related to the nuclear program, that is, nuclear research itself or nonnuclear research essential to an understanding or to an application of the associated nuclear work. As the cooperative endeavors with the universities develop, there is an increasing probability that certain nonnuclear problems will arise which would require the cooperation of the laboratories. These should be supported. Such activities might prove of sufficient significance to justify the laboratories in carrying on some work in these areas on its own initiative. Undoubtedly, as the program with Associated Midwest Universities progresses, more activities of this variety will develop. It does not appear at the present time that this is likely to provide a significant problem in the years immediately ahead, but it may become a major matter by the end of the decade.

Clearly, if other national programs could best be carried out by the Laboratory's peculiarly well qualified personnel and facilities, the Laboratory would welcome the opportunity to participate insofar as it was in fact competent and could ad-

just its other program responsibilities so as to accept the new problems. It seems possible that in the areas of interest to the National Aeronautics and Space Administration program, such participation might be profitable in the not too distant future. What other opportunities the future may hold is not clear at the present time, but flexibility to meet these opportunities when they do arise should certainly be maintained.

Sincerely yours,

NORMAN HILBERRY, *Director.*

WESTINGHOUSE ELECTRIC CORP.,
BETTIS ATOMIC DIVISION,
Pittsburgh, Pa., May 2, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Congress of the United States,
Joint Committee on Atomic Energy,
Washington, D.C.

DEAR MR. RAMEY: This is in answer to your letter of March 15, 1960, which requested comments on the report "The Future Role of Atomic Energy Commission Laboratories. Thank you for making this opportunity available. These comments are amplifications on the specific items that pertain to the Bettis Laboratory.

1. The future role of Commission laboratories by class (pp. 6–9, vol. I)

The principal element in the future program planned for the Bettis Laboratory is a concentrated development effort in those areas of water reactor technology most essential to achieving reduced plant capital costs and fuel costs in naval nuclear propulsion plants and in nuclear power generating stations such as Shippingport. The program is built upon, and will take maximum advantage of technical accomplishments to date and will result in a significant advance in the basic technology of water reactors. For this reason it will, as in the past, contribute significantly to the entire power reactor field. This additional basic technology will, in particular, provide a basis for further exploitation by industry just as occurred in the case of the *Nautilus* and first generation Navy and Shippingport developments.

2. Policies for Commission cooperation with universities and industry (pp. 9–17, vol. I)

The Bettis Laboratory has always sought and encouraged active participation by a broad segment of American industry in furnishing components for the reactor plants it is developing. This is especially true of the production phase involving the supply of components for a multiple number of reactor plants of a common design. For example, all of the reactor plant components, including the cores, for the *Skipjack* and *Skate* class submarines now under construction are being furnished by qualified vendors on a fixed price basis. This is also true of the components and cores for the cruiser *Long Beach* and the aircraft carrier *Enterprise*, now under construction at Bethlehem Ships and Newport News, respectively. Adherence to this policy has resulted in the establishment of a broad industrial base for the naval reactor program and the reactor field generally.

3. Research and development objectives of the Commission laboratories (pp. 13–26, vol. I)

The principal objective of the future development program at the Bettis Laboratory will be to advance the basic technology of water reactors to the end of achieving major reductions in both capital costs and fuel costs and for both naval propulsion reactors as well as reactors for electrical power generation. Advances in core technology in terms of lifetime capability, power capability and fuel element fabrication techniques will have the most telling effect on reducing costs for they will effect directly not only the fuel costs, but also the plant capital costs. The latter cost reduction derives from the fact that cores with high specific power capability will impose a lower burden on the plant per unit of heat removed from the core. The reductions in fuel cost derivable from increases in core lifetime or energy output, especially when combined with lower core manufacturing costs, are obvious. Thus, there is a real "payoff" in concentrating on core development in attempting to achieve reduced costs of nuclear power.

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4. Estimates of changes in work and level of effort in Commission research and development programs (pp. 27–63, vol. I)

The concurrent development and construction of a multiple number of prototype reactor plants and first-of-a-kind cores at Bettis in the last 5 years made it necessary to include a strong engineering design and procurement effort along with the development program. The workload in plant procurement and construction and in core manufacturing has dropped rapidly during the past 18 months. Further reductions are anticipated in procurement and construction type effort, with the emphasis shifting strongly to reactor development so that the latter will become the predominant activity of the laboratory in the future.

5. Future facility addition and replacement plans at Commission laboratories

No major new facilities are planned in the foreseeable future but it is noteworthy that a number of facilities important to the laboratory's development work program are nearing final stages of completion. Installation of a TRANSAC computer is completed. This high-speed electronic digital computer makes it possible to apply advanced analytical methods in the calculation on a three-dimensional basis of the nuclear and thermal characteristics of long life high performance cores. A high temperature, high pressure facility for conducting physics critical experiments was completed late last year and will be especially valuable in providing for the experimental confirmation of nuclear design methods with respect to the control and temperature coefficient characteristics of long reactivity lifetime core assemblies. An expansion of the hot laboratory which will be completed this summer will provide the added capacity for making post irradiations measurements needed for the extensive irradiation experiments associated with development of fuel elements capable of withstanding long irradiation exposure.

6. Plans to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories (p. 66, vol. I)

No comment.

7. Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary (p. 67, vol. I)

No comment.

8. (a) Planned changes in staff and program emphasis at each of the Commission laboratories (vol. I, pt. II, starting on p. 71)

No comment beyond that contained in the report.

Very truly yours,

PHILIP N. ROSS, *General Manager.*

PRATT & WHITNEY AIRCRAFT,
East Hartford, Conn., April 11, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: This is in reply to your letter of March 17, 1960, requesting our comments and views on the subjects covered in the report entitled "The Future Role of the Atomic Energy Commission Laboratories" issued by the Atomic Energy Commission to the Joint Committee on Atomic Energy in January 1960. As you may know, we participated in the preparation of this report to the extent of reviewing a draft and furnishing the Atomic Energy Commission with our comments on the report and on present and possible future programs to be assigned to the Connecticut Aircraft Nuclear Engine Laboratory. In general, we concur with the report as submitted to the Joint Committee on Atomic Energy.

With respect to the specific items in the Commission's report, our comments, which are enumerated in accordance with the attachment to your letter of March 17, 1960, are limited to those pertaining to the project engineering laboratories as a class and, specifically, to Canel. We consider that we are not qualified to make specific comments on the role of the other classes of the Commission

laboratories or on the Commission's plans for these laboratories. Our comments follow:

1. The Commission's plans for future roles of the project engineering laboratories, page 6, volume I, appear appropriate.

3. Limiting our remarks to the only category in which we are experienced, background by private industrial organizations in the manner listed as item 4, page 11, volume I. During the period from 1954 through 1957 we participated in a joint endeavor with Oak Ridge National Laboratory which resulted in our furnishing large numbers of technical personnel for assignment at the laboratory to assist in conducting a program which was the responsibility of Oak Ridge National Laboratory. We consider that this arrangement was completely successful.

3. Limiting our remrks to the only category in which we are experienced, "Special Purpose Reactors," starting on page 16, volume I, we are in complete agreement with the present research and development objectives of the program assigned to Canel and with the direction of efforts in the manned aircraft program as established by the Atomic Energy Commission, the Air Force, and by Dr. Herbert F. York, Director of Defense Research and Engineering.

4. Again, limiting our remarks to the only category in which we are experienced, "Special Purpose Reactors," starting on page 30, volume I, we are in agreement with the forecast of program trends as presented in the report. However, we have some reservations as to whether a substantial further increase in operating cost level for the total manned aircraft program will be required for the ground test program if the indirect cycle is selected for propulsion system development and a ground test prototype is assigned to Canel. Also, it should be noted, as stated on page 138 of volume I, that the technology involved in the present research and development effort may have application to other requirements in the special purpose reactors category.

5. No facility additions and replacement plans for Canel are contained in the report.

6. We consider that we are not qualified to comment on the Commission's plans for conduct of their physics and biomedical research.

7. We consider that we are not qualified to comment on the Commission's plans for maintaining the strength of the weapons laboratories.

8. (*a*) Part II, section 6, volume I, starting on page 137, contains an accurate statement as to present plans for staff and program emphasis at Canel.

(*b*) We consider that the presently expanded program assigned to Canel including planned increases in scientific and engineering personnel and corresponding increased level of effort will provide more efficient operation of Canel facilities and greater technical productivity than otherwise would be possible.

(*c*) The major emphasis in the Commission program now assigned to Canel is on advancing technology of very high temperature, compact, lightweight, liquid-metal-cooled reactors. We expect that even more advanced nuclear research and development projects will be undertaken as progress is made in the present program.

(*d*) We believe that work in the fields of nonnuclear research also should be performed where the technology, facilities, and experience are applicable and where the work is compatible with other assignments. Work in this category is presently underway at Canel and increased effort may be expected where the above-mentioned conditions are met.

We appreciate very much the opportunity to comment on the Commission report. If we can furnish any further information, please do not hesitate to call upon us.

With best personal regards.

Very truly yours,

B. A. SCHMICKRATH, *Engineering Manager.*

MASSACHUSETTS INSTITUTE OF TECHNOLOGY-HARVARD UNIVERSITY,
CAMBRIDGE ELECTRON ACCELERATOR,
Cambridge, Mass., March 29, 1960.

Mr. JAMES T. RAMEY,
Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR MR. RAMEY: I have received the report on the "Future Role of AEC Laboratories" prepared by the Commission and your request for comments.

I was pleased with the mention of the CEA in the report but do not feel that I am in a position to make proper comments on other phases of Commission activities.

Sincerely yours,

M. STANLEY LIVINGSTON, *Director.*

GENERAL ELECTRIC CO.,
HANFORD ATOMIC PRODUCTS OPERATION,
Richland, Wash., April 22, 1960.

JOINT COMMITTEE ON ATOMIC ENERGY,
Congress of the United States,
Washington, D.C.
(Attention: Mr. James T. Ramey, executive director.)

GENTLEMEN: The following comments concerning the future role of Atomic Energy Commission laboratories are submitted in response to your request of March 18, 1960. The item numbers correspond to those in the attachment to your letter.

1. I believe this part of the report might be improved by a more definitive statement of both the role of the laboratories and the classes into which they fall.

For example, I think there would be little controversy with the thesis that Government laboratories are needed and will continue to be needed to explore those areas of science pertaining directly to the acquisition of fundamental knowledge in disciplines such as physics, chemistry, et cetera, and in the general area of the life sciences including radiobiology, cancer studies, health physics, and related areas.

It seems very clear that the area of investigation mentioned in the preceding paragraph will not obtain adequate support from industry for a number of years. It is also clear that the universities (where this work might appropriately be done) will not be able to afford the very expensive and elaborate equipment that much of the investigation requires. Furthermore, certain of the investigations are definitely in the area of public health and need to be handled on a national rather than local scale, although local work by universities in several States should continue to make a valuable contribution.

With respect to the multiprogram laboratories, it is my belief that the dividing line for assignments should be at the point where prototypical projects are initiated. I believe that the laboratories should perform fundamental and applied research, and should sponsor or perform the design and construction of facilities needed for these investigations. However, it would be appropriate for the design, development, and testing of prototypical reactors, which would use this technology, to be performed by industry; although the sponsorship may appropriately remain with a Commission laboratory.

It is probably necessary that the so-called project engineering laboratories such as Knolls Atomic Power Laboratory, Bettis, and Aircraft Nuclear Propulsion continue in their present status until an adequate technological base has been established. Their status should be reviewed at that point.

It is practically certain that the portion of laboratory work devoted to support of production at production sites such as Hanford and Savannah River will decline in the next 10 years. It seems appropriate to arrange for a long-range transition to more fundamental work, making sure, however, that the basic principles outlined above are made to apply.

2. In general, I agree that the roles of industry, the Commission laboratories, and the university laboratories should be complementary. The development of these complementary functions should be done with adequate consultation and guidance on the part of all three, being particularly careful to avoid unilateral determination by the Commission.

I believe that interplay between university and Commission laboratories is very important. This interplay should take place primarily by exchange of personnel and exchange of technology, with some suitable financial support to universities in the form of equipment grants. I am generally opposed to contracts with universities since I believe they tend to isolate the contract project from the rest of the university and are self-defeating from the standpoint of disseminating knowledge. I recognize, however, that certain laboratory projects such as specific weapons developments are necessarily handled through administrative contracts between the Commission and the universities.

3. I have no comment on the research and development objectives of the Commission laboratories except to point out that a more positive approach toward strengthening free competition in private enterprise might be well-advised in those areas where the technology is sufficiently advanced. It appears that the objectives might be more firmly pointed in this direction in some areas.

4. The estimates of changes in work and level of effort in the Commission's laboratory programs appears reasonable based upon the present orientation of these establishments.

I wish to emphasize that laboratories working in either pure science or applied science need to be carefully balanced with respect to their strengths in the various disciplines. The attainment of this balance is far more important and fruitful than growth. The only value of growth, per se, is the introduction of new people and new ideas. The cross fertilization and stimulation of research effort is, I believe, obtained much more efficiently by an interchange of personnel between laboratories; between the laboratories and industry; and between laboratories and the universities.

Consequently, it is my belief that growth should not be encouraged except where it is necessary to attain balance or because of a definite increase in workload. Increases in workload may occur, particularly in such areas as biology and medicine.

Growth may also occur, perhaps inadvertently, by the laboratories becoming involved in space power systems and other new developments generally associated with the Government's role in promoting research and development in areas related to the exploration of space and of the oceans in addition to work that may be undertaken as a contribution to the national defense. If this should happen in a major degree, the Commission laboratories may, in fact, be converted into Government-owned scientific laboratories with extremely broad charters. The role of the Commission as a sponsor of such laboratories may then be brought into question. I suggest that this aspect of the situation be carefully explored on a continuing basis to determine whether such laboratories under Government ownership are appropriate, and, if so, what agency of the Government properly should be responsible for their administration.

5. I have no comment on facility additions at Commission laboratories.

6. I agree with the expressed intent of increasing the role of universities in Government-sponsored research programs. As mentioned earlier, however, I think this will only be productive in the long run if it is accomplished with a minimum of interference with the normal freedom of inquiry and the free publication of results that is typical of a university environment. I do not believe that research contracts are a good instrument for this purpose.

7. Previous comments with respect to the future role of such laboratories apply to this item.

8(*a*). In general, the planned changes in staff and program at Commission laboratories appear to be moderate and within probable future needs. However, previous comments concerning appropriate balance in various disciplines, and in particular, the comments concerning probable changes in program emphasis, will need to be considered on a continuing basis. It is unlikely that the future has been foreseen with any great accuracy in this or any other current report.

8(*b*). I do not believe that the present number of scientists and the present levels of effort will necessarily result in the most efficient operation or the greatest scientific productivity. The balance of effort between different disciplines and appropriate interchange of results with both industry and the universities together with a cross-flow of people will, in my estimation, be necessary to prevent stagnation.

8(*c*). I doubt the wisdom of having the national laboratories project oriented except in those specific cases (such as nuclear plants for flight propulsion) where project execution necessarily falls upon the Government.

8(*d*). I believe that the Commission laboratories can, by the nature of their work in the nuclear field, make valuable contributions in nonnuclear areas of investigation. As mentioned previously in these notes, however, unrestrained growth in this direction will lead to a complex of Government-owned laboratories of extremely broad scope and will raise still further questions as to the appropriate roles of such laboratories and the satisfactory method of administration. For the present, I would say that benefits arising from nuclear research should be freely applied when they are applicable to other areas, but the application should be done by entities outside of the laboratory complex if at all possible.

Very truly yours,

W. E. JOHNSON, *General Manager.*

GENERAL ELECTRIC CO.,
KNOLLS ATOMIC LABORATORY,
Schenectady, N.Y., April 28, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We appreciate very much the courtesy extended to us by the Joint Committee in requesting our comments on the Atomic Energy Commission's report regarding the future role of the AEC laboratories. I have reviewed the two volumes rather carefully and feel that, in general, a difficult and complex subject has been covered thoroughly and well.

With regard to the specific items concerning which you requested comments, I have limited my comments to those items or areas with which the Knolls Atomic Power Laboratory is directly concerned. These comments follow:

1. *The future role of Commission laboratories by class*

We review periodically with the Commission the present and future roles of KAPL. The plans contained in the report represent the current understandings and we concur in their appropriateness.

2. *Policies for Commission cooperation with universities and industry*

There are two particular areas which invite comment.

(*a*) The Commission's firm policy of achieving a rapid yet orderly progression of work from its laboratories to industry as conditions permit has been dramatically successful at KAPL. Participation of industry in our work has grown rapidly with the application of propulsion plants to ships. As the result of experience gained in working closely with industrial organizations, it is now possible to subcontract on a fixed-price competitive basis essentially all of the design and fabrication for both powerplant and reactor components. This means that the KAPL effort has been increasingly restricted to applied research and development work relating to development and design of reactor and plant systems with the related technical work in the fields of physics, chemistry, engineering, metallurgy, mathematical analysis, etc.

(*b*) The work performed at KAPL is reported in several ways and a great deal of effort is devoted to making this information available to others on as broad a basis as possible consistent with security requirements. KAPL disseminates all classified formal reports in accordance with standard AEC distribution and all unclassified formal reports in accordance with standard AEC distribution lists.

Various types of memorandums are prepared and distributed through the AEC Technical Information Service extension. In total some 300 reports are issued in a year. KAPL authors also participate in the preparation of the highly important and growing handbook series of volumes sponsored by naval reactors, and to the publication of articles in various technical journals, where some 50 technical articles are published in a typical year. We also prepare annually unclassified reports covering work performed and results obtained in each major field of technology in which the Laboratory is active. These reports are distributed broadly throughout industry and the Government. The reports are available through Government information services to all interested parties.

3. *Research and development objectives of the Commission laboratories*

The objective stated for the naval reactors program correctly describe our current efforts and have been the basis for our long-range planning. We feel they are entirely appropriate.

4. *Estimates of changes in work and level of effort in Commission research and development programs*

The projected changes in work level forecasted for naval reactors are consistent with our current understanding of the long-range programs.

5. *Future facility addition and replacement plans at Commission laboratories*

We do not foresee the need for any additional major facilities in excess of those currently authorized.

6. *Plants to continue the support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories*

No comment.

7. *Commission's intent to consider maintaining the strength of weapon laboratories by expanding nonweapons work at such laboratories if necessary*

No comment.

8. (*a*) *Planned changes in staff and program emphasis at each of the Commission laboratories*

While our present manpower is somewhat in excess of that shown for June 30, 1959, we are not anticipating any significant increase in our current level of employment nor do we feel any significant change will occur in the percentage of engineering and scientific personnel.

(*b*) *Whether maintenance of the present number of scientists and levels of effort for the various laboratories results in the most efficient operation and greatest scientific productivity*

The present staff represents the results of extremely careful selection of top quality people from both within and without the General Electric Co. About one-third of the people at the KAPL site are either engineers or scientists and for the most part represent technical fields wherein the supply of first-class talent is very limited. With such a situation, it is imperative that we make the best use possible of the skills at hand and we are continually striving to improve the efficiency and enhance the output of these people. Further, our programs are very carefully reviewed on a continuing basis. Only those programs which are clearly beneficial to naval reactors are undertaken, and when a particular program is no longer productive, it is dropped immediately. A good example of this was the sodium-cooled reactor. Once the decision was made to concentrate on pressurized water reactors, we immediately terminated all of our programs in this field and the people were made available for other work.

(*c*) *Whether greater emphasis should be given to more advanced nuclear research and development projects*

The work conducted at KAPL is now and has been of an advanced nature and we consider that it is being given appropriate emphasis.

(*d*) *Whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories*

We do not think that such work would be appropriate under present conditions in our laboratory.

I hope that these thoughts will be helpful to the committee and again wish to express our appreciation for the opportunity to comment on the report.

Very truly yours,

B. H. CALDWELL, *General Manager.*

UNIVERSITY OF CALIFORNIA,
LAWRENCE RADIATION LABORATORY,
Berkeley, Calif., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you for sending me a copy of the Commission's report on its present and projected plans for its laboratories.

As you know, we prepared reports of our long-range programs for both Berkeley and Livermore and the Commission has published summaries of them in volume II of the report. In addition, we were asked to comment on the whole report of the Commission while it was in draft form. Many of our suggestions were incorporated in the final report and we are in agreement with the conclusions reached.

A periodic review of the future role of the laboratories is a helpful thing and I think we have all benefited from it.

Sincerely yours,

EDWIN M. MCMILLAN.

UNIVERSITY OF CALIFORNIA,
LOS ALAMOS SCIENTIFIC LABORATORY,
Los Alamos, N. Mex., April 18, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you for your kindness in sending me a copy of the document "The Future Role of the AEC Laboratories." While I obviously have not had time to consider in detail the various aspects of the report which deal with laboratories other than Los Alamos, that part of it with which I am personally concerned seems to me to be rather reasonably described, and I have no particular comments to make. In the most general sense, it seems to me most important that a laboratory (and particularly a laboratory like Los Alamos) should strive always to be "light on its feet" in the pursuit of new frontiers and their application to national needs. What these may be 10 years hence no one, of course, knows, but let us keep well clear of technical ruts and technical inflexibility.

Sincerely yours,

N. E. BRADBURY, *Director.*

OAK RIDGE NATIONAL LABORATORY,
UNION CARBIDE NUCLEAR CO.,
Oak Ridge, Tenn., April 27, 1960.

MR. JAMES T. RAMEY,
Joint Committee on Atomic Energy,
Congress of the United tSates,
Washington, D.C.

DEAR MR. RAMEY: The Commission's report on "The Future Role of the Atomic Energy Commission Laboratories" is a massive piece of work for which its framers are to be congratulated. Rather than try to comment on it in detail. I shall mention two points which I consider essential, and on which I believe firm long-term policies are required.

(1) By far the most important long-term question concerning the laboratories is the same as the central question concerning AEC itself—namely, Are the present applied missions of the laboratories valid, and will the missions of these laboratories over the next 10 years retain as much validity as they had when the missions were established? I am not qualified to speak to this question as it relates to weapons development. With respect to reactor development I believe it is possible to identify the missions which are peculiarly suited to the large laboratories, and which almost surely will retain their validity a decade hence.

I conceive the central job of the nonweapons, applied laboratories—this means mainly Oak Ridge and Argonne—to be the development of the really long-range energy systems; that is, those energy systems the incentive for whose development lies not in yielding a short-term economic gain but rather in providing a permanent solution to the energy problem. The laboratories must therefore address themselves wholeheartedly and without reservation to the development of economic breeder reactors and to the development of economic, practical waste-disposal methods. Until these two problems are solved, nuclear energy will not have fulfilled its promise; to solve these problems will require consistent effort from big, powerful institutions for at least a decade, and probably more. My own belief, often reiterated, is that these problems should form the heavy backbone, instead of a rather small segment, of the laboratory programs. Of course, if there should be a modicum of success in thermonuclear research, the necessity for success with breeders becomes much less strong. My own estimate is that breeder and waste-disposal development is going to be much more fruitful than is thermonuclear development.

(2) My second point has to do with the manner in which large-scale applied projects are done within the large laboratories. It is my impression that over the past decade the principle that technical responsibility for a project must be vested in laboratory management and that laboratory management must be held fully responsible for what goes on, has suffered erosion. There are now so many layers of authority that this primary principle of good management is often painfully absent.

One way to help correct this difficulty would be to budget for those projects whose aim can be well defined on a 3- to 4-year basis rather than on a 1-year basis. This means that the project leader would be given a rather free hand for this period—but at the end of the period he would be held fully accountable for the progress or lack of progress that had been achieved. If, at the end of this time, for example, the goal were no longer deemed useful, then the project should be terminated, even though this might cause temporary dislocation.

Nuclear development is massive and slow moving. The customary 1-year budget cycle is not appropriate for this technology—the short cycle invites irresponsibility, especially since there are always many reviewers whose existence makes sharing of responsibility easy. I believe the Joint Committee would be doing the atomic energy business a great service if it somehow arranged to increase the budgetary cycle to 3 or 4 years for the big projects, and thus helped to establish a system which more strongly encourages assumption of intellectual responsibility by project managers.

Sincerely yours,

ALVIN M. WEINBERG.

THE UNIVERSITY OF ROCHESTER,
SCHOOL OF MEDICINE AND DENTISTRY,
Rochester, N.Y., April 15, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In reply to your request of March 17, 1960, for comments on the report entitled "The Future Role of the AEC Laboratories" presented to the Joint Committee on Atomic Energy of the Congress by the Atomic Energy Commission the following statement is presented.

Comment is confined to the role of the University of Rochester biomedical project in relation to the health problems of atomic energy development because we have no special cognizance of the overall operation of the Commission.

At its inception in 1943, under the Manhattan District of the Corps of Engineers the University of Rochester biomedical project accepted the assignment of setting up research programs to determine the toxic levels of chemical and radioactive materials urgently needed for the protection of workers contributing to the development of the atomic bomb. In addition certain health services were organized, such as surveying of industrial plants for hazardous conditions, consultation with industry on health problems, performing of various chemical and other analyses on human material and the maintenance of a central file of the data from medical examinations of personnel exposed to uranium.

A number of these services were more appropriate to an industrial than to an academic laboratory but they were undertaken under emergency conditions because the university had personnel on its staff or could procure personnel, with the necessary competence. Owing to security requirements the project was isolated, with respect to its activities, from the rest of the medical school in which it was principally situated. Consequently, it became an organization in the university, but not of the university, in the sense that free association and discussion were precluded.

Following the war and the placing of the contract under the jurisdiction of the Atomic Energy Commission, the industrial type of services was taken over by industry or by the Commission's Health and Safety Laboratory in New York and the program of the project has gradually attained its present character. This has features worthy of comment with respect to the integration of the academic functions of teaching and research with the fields of industrial and public health.

The project since 1948 has been administered by the department of radiation biology which is one of the regular departments of the medical school and the members of the staff hold the usual academic ranks in this school. Furthermore, the declassification of virtually all research in the biomedical area permits the free association and consultation of the project staff with that of the rest of the school.

The present program of the project includes research, consultation with AEC industrial contractors on health problems and teaching of health physics and industrial medicine and of radiation biology and biophysics.

The research is devoted largely to clarification of the industrial and environmental health problems of atomic energy development and to the medical application of atomic energy products.

Thus the project now provides an environment for students which is an integral part of a medical school, which is closely in touch with the problems of industrial and public health relating to atomic energy and in which there is active research devoted to the solution of these problems. This constitutes a very effective organization for promoting the early cognizance of health problems by scientific medicine, of bringing scientific advances to bear promptly on these problems and of acquainting students with advanced thinking in the field.

In discussing an organization of this type there arises the question of optimal size. This applies primarily to the size of the scientific staff and not to budget or facilities which are determined to a considerable extent by the nature of research problems, their requirements for equipment and space for animals and the like.

The optimal size of a research staff is determined by the requirement that there be sufficient numbers of representatives of the various scientific disciplines to deal efficiently and competently with all aspects of research problems as they arise. A study in animals of the toxicity of an airborne radioactive material, for example, may require the services of engineers, physicists, statisticians, analytical chemists, biochemists, physiologists, biologists, and pathologists for its proper conduct. Other types of problems require still other talents.

On the other hand the optimal size of a staff for effective teaching of an extensive curriculum is determined in a similar way by the necessity for competence in each of the fields being covered.

Owing to the close association of subject matter, the talents required in teaching and research coincide closely at the Rochester project. Consequently, adequate coverage of personnel for research serves the teaching program equally well. The present scientific staff of 45 to 50 represents, at any time, most of the capabilities required. A change in this number might be required by increase of the scope of the work.

Research and teaching are competitive for time and, superficially, may appear to be in conflict. However, it is generally agreed that the necessity, imposed by teaching, to review and integrate knowledge, ordinarily leads to research of improved quality. Consequently, research and teaching tend to be complementary rather than conflicting and the loss of time taken by teaching can be compensated for by sufficient technical assistance. For this reason, in an academic setting, teaching may be derived from a research program as a bonus, in considerable measure, from the costs of research.

During the current year a total of 76 students or trainees are in residence. Twenty-four of these are physicians or scientists from foreign countries who are destined for the most part to be concerned with the health aspects of atomic energy programs in their own countries. Twelve are on fellowships in health physics or industrial medicine from the Atomic Energy Commission. Eleven are from the Armed Forces or Public Health Service of the United States. The remainder are graduate students obtaining advanced training in the fields of radiation biology or biophysics to prepare for careers of teaching or research.

It is probably not debatable that the Atomic Energy Commission, in undertaking atomic energy development, must assume responsibility for the industrial and environmental health problems which it incurs. Involved in this responsibility is the insurance that contractor plants maintain adequate medical and health facilities and that the necessary research on unknown hazards be supported. The question can be raised, however, as to whether research should be done at the plant in which the hazard occurs or whether it should be done at a Central Government or academic laboratory.

The central laboratories have the obvious advantage that the volume of work permits employment of a staff sufficiently large and diversified in training and interest to handle problems competently. The additional educational advantages of academic laboratories were pointed out above. Nevertheless, certain types of hazards must be studied where they occur. Examples would be the effect of radioactive effluent on life in the environment of a plant, studies of plant personnel, evaluation of the hazards of an unusual or unique device or installation which could not be duplicated elsewhere. In certain instances these local problems may be sufficiently numerous that a substantial local staff is required to deal with them. In other instances, especially in small plants, they may be handled by field parties from central laboratories.

It will be seen from these considerations that there is no single answer to the question of where biomedical research may best be done. Presumably the distribution of research activities which has evolved under the Atomic Energy Com-

mission's Division of Biology and Medicine, in the response to various demands, is an effective practical solution to this problem.

Yours sincerely,

HENRY A. BLAIR, *Director.*

SANDIA CORP.,
Sandia Base, Albuquerque, N. Mex., April 19, 1960.

Mr. JAMES T. RAMEY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States,
Washington, D.C.

DEAR MR. RAMEY: This is in reply to your letter of March 18, 1960, asking for comments on the Atomic Energy Commission's report on the future role of the AEC laboratories. I will limit my comments to a general one on the AEC laboratories, and to a few with respect to the two laboratories operated by Sandia Corp. in Albuquerque, N. Mex., and Livermore, Calif.

Of all Federal agencies the AEC has, in my opinion, found out best how to organize and manage research laboratories. I am referring here to the so-called multiprogram laboratories. These laboratories have attracted scientists of first quality and have provided for them facilities, working conditions, and direction (or lack thereof) which has resulted in extensions of scientific frontiers as efficiently as I know it to be done anywhere. At the same time, when these laboratories have been assigned tasks with a practical objective, they have carried out the responsibilities well and on schedule. The key to the success of AEC laboratories is not easily assignable to any one cause, but it must certainly include such matters of policy as the side-stepping of civil service regulations by contract arrangements, and the assignment of only general areas of responsibilities to each laboratory and letting the laboratory management work out how best to carry out the assignment.

With regard to Sandia Corp. and its two laboratories, my first comment is to note that classifying this organization under the category of "Project Engineering Laboratories" is perhaps a bit forced. While Sandia has certainly been primarily engaged in weapon development, it has acquired very considerable capability in a wide range of scientific and engineering disciplines, and has in fact a more than modest program in basic research. While Sandia cannot be classed a multiprogram research laboratory, still to group it with four other laboratories all concerned exclusively with reactor development seems not entirely proper either.

Under the assumption of a continued moratorium of nuclear testing, the future activities of Sandia must be given serious consideration. As long as nuclear weapons remain an important part of our Nation's arsenal, there will, of course, always be work for Sandia to do updating and monitoring these weapons. On the other hand, such work cannot occupy all of Sandia's present staff or make full use of its extensive facilities. But more importantly it will not provide the challenge needed to maintain a vigorous organization intact. In my opinion, it is therefore vital that Sandia's charter be broadened to include nonweapon programs, if the moratorium on nuclear testing is continued indefinitely. This is the only way that a nuclear weapon capability can be maintained in reserve as insurance against the possibility that the international situation will require its buildup in the future.

Sandia has today a large and capable technical staff (the largest, in fact, of all the AEC laboratories) with extensive laboratories and facilities which could be applied to a variety of problems. Even aside from the national defense question, it seems only commonsense, therefore, that the Sandia establishment be considered as a national asset and used in other technical problems of nation interest.

Sincerely,

J. P. MOLNAR.

APPENDIX VI

COMMENTS RECEIVED FROM OTHER INTERESTED GROUPS

ATOMIC INDUSTRIAL FORUM, INC.,
New York, N.Y., April 18, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In response to your letter of March 11 requesting comments on the report on the future role of AEC laboratories, I am enclosing a copy of a paper entitled, "Atomic Research and Development—The Role of Industry." This report, prepared by the Forum's staff at the request of the Forum's executive committee, covers many of the questions discussed in the AEC report, particularly as regards industrial participation.

I think it might be worthwhile to state the conclusions and recommendations which this report makes:

"The maintenance of American leadership in developing the peaceful uses of atomic energy requires that a conscious effort be made to build a strong atomic industry at the same time a vigorous program of research is undertaken in the AEC laboratories and in our universities. These twin objectives of national policy have for some time been generally recognized by the Commission in the conduct of its research and development program, but we believe there is room for improvement in the interest of achieving our common goals.

"In particular, there is a need for clarification of the Commission's policies and intentions with regard to the placement of future work under the AEC's research and development program. In this regard, the following steps might usefully be taken:

"1. Establishment of a more effective system of transmitting to industry the views and plans of the AEC for future research and development, as a basis for industry's own forward planning. This might include periodic reports on the kinds of activities which the Commission feels are ready for transition to industrial development and those which appear to be susceptible of commercial development at a later time.

"2. Establishment of a more effective mechanism for presentation of industry ideas and proposals to the Commission in the field of research and development.

"3. Establishment of an ad hoc committee, appointed by the Commission, to discuss the respective roles of industry, the universities and the AEC-owned facilities in research and development."

It should be pointed out that these are conclusions arrived at by the Forum staff, and do not purport to be those of the Forum membership. We have not canvassed them and therefore are not able to present any summary of their views.

We appreciate the opportunity to contribute to the committee print to be published on "The Role of the AEC Laboratories" and hope that the enclosed paper will be helpful in delineating problems in this area which have been of most direct concern to the atomic industry.

Sincerely,

FRANCIS K. MCCUNE, *President.*

Atomic Research and Development—The Role of Industry [1]

(A report prepared by the Atomic Industrial Forum staff, New York, N.Y., February 12, 1960)

INTRODUCTION

The rapid development of the peaceful uses of atomic energy in recent years is attributable in part to the excellent spirit of teamwork which has prevailed between the people working in the AEC-owned research and development laboratories and their counterparts in private industry and the universities. This spirit of cooperation has been nurtured through a common desire to maintain American leadership in this field and the belief that such cooperation will redound to the benefit of all concerned.

The AEC laboratories, while owned by the Government, have from the beginning been operated by private industrial and university contractors. Over the years this method of operation has proved to be a sound and productive one and the laboratories have made vital contributions to the advancement of nuclear science and technology in this country. At the same time, some of the laboratories have made a significant contribution to atomic development through placing certain portions of their research and development work outside for industry competition. Such cooperation has resulted in augmenting the effectiveness of the laboratories' efforts and in increasing the Nation's industrial capability or "know-how" in the atomic field.

With the emergence of a large scale research and development effort in support of the AEC's peacetime program, the problem has arisen as to how the R. & D. workload should best be distributed, both now and in the future, so as to insure maximum progress toward our common goals. It is the purpose of this statement to outline certain aspects of this problem and to delineate some of the major issues involved.

Because of the Forum's composition and responsibilities and because the activities of the AEC laboratories are the primary responsibility of Government, particular attention is focused here on the role of industry. It is recognized that the universities are also making a major contribution to the AEC program, particularly in the field of basic research, but because of the differing nature of their relationship to the AEC laboratories, their activities will not be dealt with in detail in this report.

The statements in the report are made with the full acknowledgement that no precipitate changes in AEC policy are either expected or desired. As in all such matters involving important national considerations, there are no pat solutions to the complex questions at issue.

It is recognized that the Atomic Energy Commission must carefully weigh its actions in the light of a number of considerations, many of which extend beyond the scope of issues to be outlined here, always keeping the national interest as its paramount guide and objective.

The national interest can best be served, in our opinion, by clarity of purpose and conscientious adherence to broad national objectives or goals, as expressed by the Congress and the President. The goal we are concerned with in this instance is the fostering of U.S. leadership in the peacetime development of atomic energy, both for the benefit of our own citizens and those in other friendly nations.

THE BUILDING OF A STRONG ATOMIC INDUSTRY AS AN ESTABLISHED NATIONAL OBJECTIVE

In addition to the express declarations of the President, beginning with his historic atoms-for-peace speech to the United Nations General Assembly in 1953, one of the principal guides in this field is the Atomic Energy Act of 1954.

Among the major objectives of national policy, as specified in the act, is "to strengthen free competition in private enterprise." In order to carry out this and other major aims of our peacetime effort, the act provides for establishment of a research and development program designed "to encourage maximum scientific and industrial progress." It also calls for a program "to encourage widespread participation in the development and utilization of atomic energy for

[1] This report was prepared by the Forum staff at the request of the executive committee of the board of directors and was approved for publication by the executive committee.

peaceful purposes." One of the chief purposes of these provisions was to remove peacetime atomic development from complete Government monopoly, as it had been prior to the 1954 act, and bring to bear the unique capabilities of private industry and the universities in development of the peaceful uses of atomic energy.

Ultimately the act envisioned, and statements by the executive branch confirmed, the intent to shift the burden of peacetime atomic development, in its practical applications, from the Government to industry. It was recognized from the outset that this would be an evolutionary process and experience in the interim has pointed to the difficulties involved in the period of transition. Despite these difficulties, industry has come a long way since 1954 in building up its capacity to carry out the intent outlined above.

In a document notable for its farsightedness in identifying future obstacles to our peacetime effort, the so-called McKinney Panel report to the Joint Committee in 1956, this problem was clearly stated, with particular reference to the importance of Commission policy on research and development in shaping our peacetime program. Thus, the panel report noted that "Commission research policy * * * can encourage or discourage widespread participation. It can strengthen or weaken * * * the roles of Government and private enterprise."

Noting that the Commission laboratories serve a vital role toward both military and peaceful ends, the report goes on to point out that the tasks involved in bringing atomic energy development to fruition are "beyond the capabilities of the Commission alone" and that "increased participation by others is essential if the economic and humanitarian benefits attainable are to be achieved."

The report observes that "the balance between continued Commission research strength and the healthy growth of non-Commission participation requires that the Commission continue its own present work but look toward the ultimate objective of concentrating on the frontiers of research."

During the transition, the report points out, "The Commission must avoid competition with willing and vigorous efforts by others * * * and encourage participation by others through research contracts wherever its own program will benefit thereby."

For industry to participate effectively, the report emphasizes, industry must have "assurance that the Government exert its present [1956] superior research capability in a manner calculated to encourage and supplement industrial initiative and investment."

The report concludes that "during the present transition from all-Government to Government and private responsibility for the conduct of applied research and development relating to the peaceful uses of atomic energy, a more equitable sharing of the burden should be the constant objective of the Commission and of industry."

SHIFTING THE BURDEN FROM GOVERNMENT TO INDUSTRY

In the 4 years since the McKinney Panel report was submitted to the Joint Committee, the validity of these comments and conclusions has not diminished. In the interim, both industry and the universities have done their part in preparing for this transition by augmenting their own resources and capabilities many times what they were in 1956. These researches have supplemented the substantial investment which has been made by the AEC in its own facilities and offsite contract work.

In line with the declared intent of Congress and executive branch of the Government, we believe it is a valid assumption to state that one of the major objectives of our peacetime research and development effort is gradually to shift the burden of atomic power development from the Government to industry and to reach the stage where Government assistance can be eliminated, or substantially reduced. Such an objective was foreseen in the report on power reactors issued on January 2, 1959, by an ad hoc committee appointed by the Commission to recommend a 10-year program for atomic power development. This report is being utilized by both the Joint Committee and the AEC as a basis for formulating the future scope and direction of the atomic power program.

The shifting of the burden of responsibility for atomic power development from the Government to industry implies that during the period of transition, the Government will assist in preparing industry for its new job. One of the mutually beneficial ways of providing such assistance during this transition period, when normal economic incentives are absent, is through the award of increasingly difficult and significant research and development work to be carried out under contract in privately owned facilities. Such contract work enables the

Government to take advantage of certain capabilities inherent in industry while at the same time carrying out the objective of building up a strong industrial base upon which the future of atomic power development must rely.

In this connection, a clear distinction should be made between private industrial facilities which perform both Government and commercial work, and those industrial facilities which have as a condition of their Government contracts that nothing but Government work will be undertaken. It is in the former, or independent, laboratories where the need arises for practical experience in building up industrial capability.

The important point to keep in mind is that an orderly transfer of more responsibility to industry, as a necessary step in the successful achievement of our national goals, presupposes an intimate working knowledge by industry of atomic energy development and application. The transfer of information developed in the AEC laboratories is, of course, helpful, but there can be no substitute for practical experience. Essentially, industry can only learn by "getting its feet wet" in the development of nuclear components, processes, and systems. In the course of this work, certain benefits in the field of product improvement and refinement are bound to accrue to the benefit of all.

Beyond this, industry must perform more research and development in its own facilities if it is to become knowledgeable and capable of guaranteeing the equipment it produces. The commitment of increased private capital as the program evolves is dependent, at least in part, on industry's confidence that it has the actual know-how and trained people in its own facilities to underwrite such guarantees.

At the same time, industry has a firm responsibility to analyze its own program and efforts with a view to improving its own capabilities. This might include examination of industry's readiness to take on research and development work on shorter time schedules to meet AEC needs.

GROWTH OF RESEARCH AND DEVELOPMENT PROGRAMS

Problems associated with the growth and distribution of the AEC research and development program may be considered in the framework of the overall increase in the national effort in recent years. Total Federal expenditures for R. & D. in the President's budget for fiscal 1961 are estimated at $8.4 billion, including expansion of plant facilities. This represents a dramatic jump of some 86 percent over the $4.5 billion spent by the Government 3 years ago and reflects the steady upward trend in the past 10 years.

One of the main elements in this large expansion has been Government investment in major R. & D. facilities. Present R. & D. facilities in AEC laboratories are estimated to be worth about $1 billion, and an additional $460 million in facilities are under construction or have been authorized. Of existing facilities, about $625 million are in reactor plant and equipment. In all, about 40,000 people are employed in the 20 largest facilities, of which 11,000 are scientists and engineers.

While some of these increases in AEC facilities are attributable to the weapons program, the rapid growth of nonweapons R. & D. facilities, together with their large annual carrying costs, have raised the question as to whether there should not be some practical limitation on the size of these installations, among other things to maintain efficiency and flexibility in the AEC research program. A companion question is raised as to whether this rapid growth in facilities, particularly those connected with advanced development work and product improvement, is consistent with AEC's responsibility to assist in the establishment of a strong industrial base.

The trend in AEC expenditures for research and development has also shown a marked upward swing in recent years. Total AEC expenditures in fiscal 1960 for research and development, excluding weapons, is expected to run about $625 million, an increase of about $100 million over 1959.

Of the $625 million for 1960, $400 million or about two-thirds of the total will be spent in the 20 largest AEC laboratories, while most of the balance of $225 million, or about one-third of the total, will be spent "offsite"; that is, contracted out to industry and universities. The offsite figure for reactor development as a whole has, encouragingly, more than doubled in the past 2 years. About 30 percent of all reactor R. & D. work in 1960 will be conducted offsite, compared with 18 percent in 1958.

In the area of civilian reactor development, total R. & D. expenditures for fiscal 1960 are expected to be about $119 million. Of this amount, $71 million

or about 60 percent will be spent in AEC laboratories and $48 million or about 40 percent will be contracted out.

In the related field of general nuclear technology, involving the fuel-cycle program, isotope separation, reactor safety, reactor physics, chemical processing, and component development, R. & D. expenditures will be about $46 million for fiscal 1960, of which $26 million or 55 percent is to be spent in AEC laboratories and $20 million or 45 percent contracted out.

It is apparent from the above figures that one of the most difficult problems in connection with the growth of the AEC research and development program is found in the projected expansion of nonweapon facilities at the AEC laboratories, particularly those which are related to development work that is well advanced toward industrial application. This raises the basic question as to what influence this continued expansion will have on the future effectiveness of the R. & D. program, both in the laboratories themselves and outside the laboratories in industry and the universities. It is recognized, of course, that this is a matter for decision by the Commission.

With regard to the pattern of operating expenditures for the Commission's R. & D. program, note should be taken of the apparent efforts which the Commission has made in the past 2 years in placing increased R. & D. work in industry and in the universities. This pattern is in the right direction and should assist measurably in advancing the program as a whole.

BACKGROUND OF FORUM CONSIDERATION

About a year ago, the directors of the forum were asked to identify the major problems which are facing the atomic industry as an indication of which areas need concentrated attention and study. One of these problems was the respective role of industry and the AEC laboratories in future research and development work.

One of the board members, Dr. Henry D. Smyth, was asked to consider this problem and to make recommendations to the board on ways in which the forum might address its efforts to this area of interest. The matter was discussed with a number of people in the field, including principals of the AEC. As a result, the forum wrote to the Chairman of the AEC to express interest in the subject and to suggest that the matter receive further study by an ad hoc committee to be appointed by the Commission.

Subsequent to this suggestion, the Commission wrote the forum to state that in the preparation of the Commission's report on the AEC laboratories, to be presented to the Joint Committee on Atomic Energy in January, the Commission believed it would be helpful to have the forum's views. In response to this invitation, the forum convened an informal seminar September 10 to which 37 individuals with knowledge and experience in this area were invited. In addition to industry and university representatives, the seminar was attended by the directors of four of the major AEC-owned R. & D. installations and an AEC observer. Dr. James B. Austin agreed to chair the seminar, in the absence of Dr. Smyth who was in Europe.

Following this seminar, members of the forum met with the Commission and principal staff November 23 to present views on the present and future R. & D. program and to report on the results of the seminar. Dr. Austin chaired the forum group and a summary presentation was made by Mr. Carroll L. Wilson, rapporteur of the earlier seminar.

DISCUSSION OF MAJOR ISSUES

While the Commission has not expressed a formal point of view or taken any official action on this matter, in view of the projected hearings on the AEC laboratories by the Joint Committee, we believe it would be useful to summarize the main points raised by the forum group in its meeting with the Commission:

A. Objectives of national policy

There should be no inherent conflict in pursuing the twin objectives, as spelled out in the Atomic Energy Act, of building a healthy atomic industry and at the same time insuring that a vigorous research and development program is carried out at the AEC laboratories. In fact, the two complement each other and should be looked upon as parallel endeavors contributing to our common goal of U.S. leadership in the peacetime uses of atomic energy. This goal can only be

realized if a conscious and determined effort is made to pursue both objectives at the same time and with equal vigor.

B. Need for clear AEC policy

One of the chief questions arising from discussions on the Commission's future R. & D. work program is whether or not a clear AEC policy exists today for effectively carrying out the twin objectives of building a healthy industrial base, on which the burdens of atomic power development must eventually rest, and furthering needed research efforts in the AEC laboratories. A related question is whether, if such a policy does exist, adequate guidelines have been provided to the AEC staff and field offices to insure uniformity of approach up and down the line.

C. Need for practical experience in industry

The question also arises as to whether present plans for achieving economic nuclear power, both here and abroad, can be met unless a conscious effort is made to provide industry with the opportunity of obtaining maximum practical experience in atomic technology. In the present period of transition such opportunities must, of necessity, be provided largely through AEC research and development work. Later, as economic incentives increase, industry may be expected to assume a larger share of the financial burden.

D. Correlating industrial capability with AEC requirements

A related question is presented as to what, if any, mechanism exists to correlate industrial R. & D. capabilities with AEC requirements. In the case of the AEC laboratories, the annual budget submission serves as a periodic device for the laboratories to learn of the AEC's intentions for the future and to make known their own ideas and proposals for funding projects. No such regular mechanism exists for industry, either to contribute its own ideas and proposals or to become informed on the AEC's future R. & D. program plans and objectives.

E. Maximizing effectiveness of AEC laboratories

The AEC laboratories, together with the industrial and university contractors who operate them, are currently making important contributions, as they have in the past, to the country's scientific effort. The important thing which should be borne in mind is that as atomic technology develops, it is desirable for all concerned that certain areas of applied research and development, which industry is especially qualified to do, should as time goes on be placed to an increasing extent in industry-owned facilities. This would free the competent teams of scientists in the AEC laboratories to pursue the advanced type of research and applications which they are uniquely set up to do. The problem is to develop a means of making such judgments on a sound and orderly basis.

F. Competition with industry

A problem separate from but related to future AEC policy on contracting out R. & D. work is the question of present activities in AEC installations for which industry has a demonstrated capability. Examples of this may be found in the manufacture of certain nuclear fuels and the fabrication of reactor instruments and control devices. Such direct competition, aside from the wasteful duplication involved, has an inhibiting effect on the investment of private capital and the normal commercial development of atomic hardware. Attention should also be given to measuring existing industrial capacity and capability for testing atomic hardware before considering the construction of additional test reactors.

G. Proprietary information and rights

The Atomic Energy Act provides the AEC with certain limits regarding the award of proprietary rights for inventions which are developed in the course of Government contract work. However, there are some instances where private firms are investing large sums of their own in such work and are contributing proprietary knowledge developed by the company prior to acceptance of the Government contract. Quite often individual firms are asked to give up existing proprietary rights on previous work as a condition to obtaining AEC contracts. In these and similar instances, the equities of the situation should be weighed carefully by contracting offices in the field and in the Commission to insure that legitimate proprietary interests are taken into account. This is an important factor in eliciting a maximum contribution from industry.

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CONCLUSIONS AND RECOMMENDATIONS

The maintenance of American leadership in developing the peaceful uses of atomic energy requires that a conscious effort be made to build a strong atomic industry at the same time a vigorous program of research is undertaken in the AEC laboratories and in our universities. These twin objectives of national policy have for some time been generally recognized by the Commission in the conduct of its research and development program, but we believe there is room for improvement in the interest of achieving our common goals.

In particular, there is a need for clarification of the Commission's policies and intentions with regard to the placement of future work under the AEC's research and development program. In this regard, the following steps might usefully be taken:

1. Establishment of a more effective system of transmitting to industry the views and plans of the AEC for future research and development, as a basis for industry's own forward planning. This might include periodic reports on the kinds of activities which the Commission feels are ready for transition to industrial development and those which appear to be susceptible of commercial development at a later time.

2. Establishment of a more effective mechanism for presentation of industry ideas and proposals to the Commission in the field of research and development.

3. Establishment of an ad hoc committee, appointed by the Commission, to discuss the respective roles of industry, the universities, and the AEC-owned facilities in research and development.

CHAMBER OF COMMERCE OF THE UNITED STATES,
Washington, D.C., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Thank you for your invitation of March 11, 1960, to comment on the Atomic Energy Commission's report on "The Future Role of the Atomic Energy Commission Laboratories."

Attached are our comments on the report and the specific items appended to your March 11 letter. These comments were prepared in cooperation with representatives of the atomic energy industry and universities interested in atomic energy research. They reflect the application of chamber of commerce policy, adopted by our membership, to the future role of AEC laboratories.

The Joint Committee on Atomic Energy is to be commended for exploring this important subject and we appreciate this opportunity to express our views on a matter so vital to the Nation and the atomic energy industry.

We look forward to the publication of the AEC report and the comments you receive; and feel certain that they will make a valuable contribution to a better utilization of the laboratories, industry and universities.

Cordially yours,

CLARENCE R. MILES.

COMMENTS ON "THE FUTURE ROLE OF THE ATOMIC ENERGY COMMISSION LABORATORIES," REPORT OF THE ATOMIC ENERGY COMMISSION TO THE JOINT COMMITTEE ON ATOMIC ENERGY, FEBRUARY 1960

The Chamber of Commerce of the United States recognizes the great value of the Atomic Energy Commission laboratories and the contributions they have made. We look forward to an increase in their value and new and important future contributions.

It seems to us that the determination of the future role of these laboratories is a discussion of how to achieve the best balance between the activities and programs of the laboratories, industry, and universities. The Atomic Energy Commission is charged with several responsibilities which could be in conflict if the role of the AEC laboratories is not in balance with a continuously increasing role for industry and universities. We know of no other proven way to world leadership in any field of technology and its related sciences than through reliance on industrial and university capabilities. It is, therefore, imperative that the future role of the AEC laboratories be planned in such a way as to encourage rather than discourage greater participation of industrial and academic institutions. Indeed, an important part of their role must be to accelerate the process

of bringing both the industrial and academic resources and skills of the Nation to bear upon the development of atomic energy.

It is our hope that the comments which follow concerning the future role of AEC laboratories will serve to further sharpen some of the general language and statements of policy in the AEC report. (The headings, pages, and quotations that follow are from the AEC report.)

The laboratories—National assets (pp. 4–6)

The AEC laboratories are valuable national assets if properly used. In this regard we agree heartily with the statement that "The laboratories are an effective means for integrating the scientific and technical capabilities of the Nation through their complementary position with respect to the universities on the one hand, and industry on the other" (p. 4). However, an examination of the expenditure of dollars in the atomic energy program as between the laboratories and industry and universities shows that this "complementary position" has not been achieved. We suggest that the Joint Committee and the Commission continuously examine the relative expenditure of funds in the laboratories and industry and universities as one means of evaluating the relationship and with a view toward achieving a complementary, rather than dominant position on the part of the laboratories.

Specifically, an aggressive program designed to turn over research and development programs to industrial and university laboratories could be expected to return substantial dividends in addition to achieving this desired "complementary position" of the AEC laboratories. The entire atomic energy program would benefit by the broader base of technical manpower, and some of the development costs would be carried by industrial participants as profit opportunities become apparent.

The report states that "In addition to the strength of their permanent staffs, these laboratories are organized to encourage participation of scientists and engineers of universities and industry" (p. 5). We hope that before long this encouragement of the participation of universities and industry will become a major function of the AEC and its laboratories. In this connection the continuous review of the balance of expenditures between the laboratories and industry and universities should provide a major method of determining the degree to which the AEC has been successful in carrying out this policy.

The statement that "They (the laboratories) are a principal source of new ideas for scientific programs and of suggestions and advice as to the approaches toward which major efforts should be directed," (p. 5) is true, but this should not be overemphasized to the point of failing to recognize the great value of our universities for this purpose, and their traditional role in making major contributions to scientific knowledge. An overemphasis of the laboratories could lead to inadequate reliance upon the many universities who could make major contributions to this effort if given encouragement and opportunity. The handful of universities, which are involved in the AEC laboratory program, account for just a small part of the total scientific skills available at our universities and an overstress on the laboratories could mean an underutilization of university skills and talent, thus failing to realize maximum benefits to the Nation in both research and education.

Commission assessment of its laboratories: Roles for the future (p. 6)

We agree completely with the statement that "It (the Commission) believes that great scientific strength has been attained through the cooperation of industry, the universities, and the laboratories and that even greater achievement may be anticipated in the future through intelligent use of all of these institutions" (p. 6). We believe that this will require greater use of the skills of industry and universities and we would like to see concrete plans on the part of the Commission for bringing this about.

Multiprogram laboratories (pp. 6–8)

In the definition of the function of multiprogram laboratories it is noted that "advancing the frontiers of knowledge in the sciences is a basic mission of the Commission" (point 1, p. 7). We recognize that the impossibility of predicting which areas of knowledge will eventually lead to the advancement of atomic energy development makes the statement necessary. We hope that in recognizing this mission the Commission will relate it to atomic energy development insofar as possible and eventually discharge this mission largely through the universities and industries of the Nation rather than undertaking it to such a large degree through the limited structure of the national laboratories.

We agree with point 2 of page 7 that "nuclear weapons development is a prime responsibility of the Commission and, in turn, of these laboratories * * *."

Point 3 of page 7 states in part that "* * * it is appropriate for the investigations and developments of the laboratory to be carried through demonstration of technical feasibility and far enough to provide a basis for judging probable economic worth of the concept." It is understood that on occasion a laboratory must undertake projects to determine technical feasibility of processes. However, the evaluation of the technical and economic feasibility of processes, constitutes a major function of industry in the conduct of its own commerical practices. Indeed, the market value of a concept can only be determined by the free forces of supply and demand. We urge, therefore, that the national laboratories resort to greater use of the staff and facilities of industrial groups in such evaluations, instead of diverting laboratory technical groups and installing expensive capital equipment which later become burdens on economy of operation. As to determining the economic feasibility of processes, we consider that the performance of this function is entirely inappropriate for the laboratories and should be assigned to industry.

The statement in point 4, page 7 which reads: "From time to time, the Commission will utilize these laboratories and their staffs for other urgent tasks or projects of importance to the Nation" is so broad and unspecified that it is difficult to appraise. Assuming a proper evaluation of the urgency and importance of a given task, it is important that the Commission undertake it only when there is no other approach in order to avoid dilution of effort and accomplish a proper balance of strength.

We concur with point 5 of page 7 which states in part that, "These laboratories have a continuing major role in aiding the Commission in the rapid dissemination of new knowledge to the scientific and technical community."

Point 6 of page 8 should be broadened to make it clear that the laboratories will not be the only or major source of technical evaluations and advice. Such advice should continue to be sought from outside the laboratories with greater reliance upon industry and universities.

Laboratory, university, and industry relationships (pp. 9–12)

We are pleased to note the statement that "the Commission laboratories, the universities, and industry have complementary parts to play in conducting atomic energy research and development." We interpret this to mean that the Commission must assure that the laboratories complement industry and universities. We believe this to be an important objective of the Atomic Energy Act of 1954. Much progress has been made toward increasing the roles of industry and universities in the nonmilitary atomic energy effort since secrecy restrictions were removed.

On the other hand, the fact that the Nation's tax dollars are being largely spent through Government-owned installations indicates that the "tail still wags the dog." There remains much to be done to "normalize" the atomic energy field and to make the functions of the AEC laboratories indeed complementary.

We applaud the statement that reads, "The discussion does envisage an orderly progression to industry of development projects undertaken by Commission laboratories. The Commission intends to encourage this progression and to support, through appropriate contracts with industry, such further development as warrants continued Government support." We suggest the desirability of measuring the success of this "orderly progression" policy with the actual dollar decrease in the budgets assigned to the laboratories for particular development projects.

The Commission's appreciation of the importance of communicating information to outside groups is good. The cooperation described for this communication, on page 11, is to be commended. On the other hand, we must not lose sight of the fact that the current importance of the AEC laboratories as a source of nuclear science and technology, is a temporary situation that cannot compare, over the long run, with the vaster strength, resources, and diversity of our industries and universities.

We congratulate the Commission on the excellent policy statement on page 12 which reads "The Commission believes that the laboratories can continue to undertake new projects and work in new areas without proportionate expansion of their size. To accomplish this aim, the Commission will transfer work to others, or will bring it to a conclusion, when the Commission's needs have been satisfied, when other research performers have developed the necessary capability, or when the work is judged to be less productive than is another

project with which it competes for laboratory attention." We believe that substantial effort on the part of AEC will be required to achieve this objective. The AEC must assure that the availability of "other research performers" is continuously sought and made apparent in order that the transfer of work is always being promoted.

Controlled thermonuclear research (pp. 20–21)

We recognize the role of the laboratories in this difficult program. However, we believe this is a good example of an area where wider utilization of university and industrial laboratories should be made. We suggest a greater emphasis on supporting work at the places where the "brilliant minds" are presently available and the encouragement of broader university participation which will result in the development of additional ideas and competent graduates in plasma physics and electrodynamic control.

Isotopes development and training (pp. 23–25)

While progress has been made in educating the Nation on the potentials and problems of atomic energy applications, much remains to be done. We believe that continuously greater reliance should be placed upon the educational institutions of the Nation so that they may play a larger role in preparing the Nation for more widespread uses of atomic energy. While the educational programs offered by Oak Ridge are useful in bridging a temporary gap, we hope that such educational functions will be encouraged to develop in educational institutions in order to spread their usefulness.

Also, while the use of radioactive isotopes has increased significantly, we believe that much more needs to be done to promote basic research and education in universities, and applied research in industries, to achieve the full potential inherent in this broad area. We would like to see greater stress on research and development in radioisotopes, radiochemistry research, and in the basic chemistry that makes use of these techniques.

Metallurgy and materials (pp. 48–49)

We agree that greater support is necessary in the metallurgy and materials fields. However, we hope such support will take the form of supporting research and development in universities and industry rather than in the expansion of facilities and the establishment of new laboratories at Government-owned sites.

Summary and conclusions (pp. 63–69)

There are many statements in the "Summary and Conclusions" of this report that we support, especially the statement which reads: "With some specific exceptions, the facilities and the staffing of the laboratories appear to be equal in scope to the responsibilities that lie ahead for them. They are mature institutions, and incremental growth will be permitted only where necessary." Here again, implementation of the policy is paramount. We will not comment on the reports of individual laboratories that comprise volume II except to say that there appears to be some inconsistency with the Commission's plans as outlined in volume I. We assume that the prinicples set forth in this "Summary and Conclusion" section are the basic policies of the Commission. We hope they will be vigorously pursued and implemented.

Vigorous application of the policy discussed above together with the statement that "The increasing capability of industry and the universities, built in part by the work of the laboratories, makes it possible for the Commission to turn to industry and to the universities to an increasing extent as the program expands" will go far toward accomplishing the objectives of the Atomic Energy Act of 1954.

We applaud the statement on page 66 that "It is Commission policy to promote the participation of industry in the nuclear field on an increasing scale and to transfer to industry, as industry indicates its capability to perform, operations or functions now being performed in Government facilities." Again, we repeat our suggestion that the Joint Committee and the Commission continuously examine the degree to which this policy is made effective in practice; and that one test of its effectiveness is the actual dollar decrease in the budgets assigned to the laboratories for specific functions.

The Commission is to be commended for its statement of policy that "The support of a relatively greater increase in basic physical research and in biomedical research in the universities than at the laboratories * * *." And its recognition that "Research at the universities yields as a byproduct the training of additional scientists—essential to staff the growing demands of research

and development institutions throughout the economy and to maintain the United States in the forefront of scientific and technical affairs" (p. 66). We believe this principle needs greater emphasis than it receives in the report.

We understand the reasons behind the Commission's desire to maintain the strength of weapons laboratories. However, we are concerned with the possible detrimental effects of considering the expansion of nonweapons work at such laboratories if necessary (p. 67). Such a policy, in the absence of limiting details, could serve to discourage the expansion of industrial and university capability which is a major objective. We endorse the following principle which is stated in connection with production plant laboratories and recommend its application to the weapons laboratories: "As new tasks need to be undertaken, the capabilities of these laboratories will be carefully assessed, particularly if such assignments would otherwise call for expanding Government facilities elsewhere, or expanding the personnel of another Commission laboratory. But there is no intention to assign them tasks that can more appropriately be performed in private facilities, or to transfer going activities from other laboratories; 'make work' tasks will not be resorted to as a means of maintaining the vitality of these institutions" (p. 67). The application of this principle to the weapons laboratories would promote private participation in the atomic energy program while maintaining necessary weapons laboratory capability.

In summary, we wish to make it very clear that we recognize the essential role that the AEC laboratories play in the advancement of nuclear science and technology. The overall approach which AEC has taken in this report to the planning of their future roles is a good one. We caution, however, against permitting the laboratories to exercise functions which can be carried out more appropriately elsewhere. The very presence of such functions would tend to dissipate and dilute the efforts of the laboratories in areas in which they are especially well equipped to make contributions; and retard greater industrial and university participation.

EDISON ELECTRIC INSTITUTE,
New York, N.Y., April 21, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: This letter is submitted on behalf of the Edison Electric Institute Committee on Atomic Power in response to your letter of March 11 requesting comments on the report of the Atomic Energy Commission on the future role of the AEC laboratories.

Because of the institute's concern with the development of nuclear energy only as it pertains to the production of electricity, we generally will limit our comments to the AEC laboratory activities in this field.

We further believe that we are best equipped to discuss the appropriate general roles of Government and industry in the field of research and development rather than specific laboratory activities. Thus, our comments will be of a broad nature, although we will cover those specific items listed in your letter that are pertinent to our industry.

We have on several occasions expressed our views on the proper role of Government in the development of nuclear energy, most recently in our "202" statement before the Joint Committee on Atomic Energy (Feb. 24, 1960). However, in view of your request and the importance of attaining a proper balance between Government and industry responsibilities we believe our remarks bear repeating.

As we indicated in our "202" statement, the institute concurs in the civilian nuclear power program objectives of the AEC. We believe that the AEC laboratories have a proper role in the attainment of these objectives, but we wish to point out as we have on previous occasions that the development of nuclear power should be brought as soon as possible and as nearly as possible within the framework of commercial development of conventional energy sources. The AEC laboratories activities should be directed toward the achievement of this additional objective.

In this regard we are in agreement with and are encouraged by such statements in the AEC report as "* * * the role of the Commission laboratories * * * does not assume that the laboratories will be assigned exclusive areas of work

for which they alone will receive Government support. Research and development work warranting Commission support will continue to receive full consideration whether the proposal is from industry, a university, or a Commission laboratory."

The AEC also indicates in its report that the Commission laboratories should utilize to the maximum extent possible the services that industry can provide. We are in complete accord with this and hope that the AEC will give maximum attention to this principle in its future development programs and negotiations with industry. In fact, only when specific facilities do not exist in industry should Government-owned facilities be used. We realize and believe that the AEC laboratories should be kept strong enough to do necessary work in weapons development and fundamental research not economically possible for industry to perform, but we do not believe it is in the best interest of our country to have Government in competition with private industry in any phase of nuclear development that can be adequately performed by industry. In our free enterprise system, Government functions should be restricted to those activities that private industry cannot perform.

Another important consideration in the future role of the AEC laboratories is their disposition in case of reduced requirements for their services. We commend the AEC in stating in its report that "make work" tasks will not be assigned to any facilities such as the production laboratories as a means of "maintaining the vitality of these institutions."

In discussing the functions of the multiprogram laboratories the Commission has indicated that, "* * * it is appropriate for the investigations and developments (concerning new concepts of stationary reactors) of the laboratory to be carried through demonstration of technical feasibility and far enough to provide a basis for judging probable economic worth of the concept." We interpret this to mean endeavors up to and including project development (as defined in the AEC report) with appropriate reactor experiments and perhaps prototype reactors, but certainly not beyond this point of development. And we believe, in keeping with the principles we have cited, that industry should perform as much of this development work as it is qualified to handle.

We further believe that industry is better qualified to judge the probable economic worth of a reactor concept and consequently we believe that economic evaluation should be a function of the competitive judgment of industry.

We appreciate this opportunity to discuss the AEC report on the future role of the Commission laboratories, and hope our comments will be useful to you.

Sincerely.

ELMER L. LINDSETH,
Chairman, Committee on Atomic Power.

NATIONAL ASSOCIATION OF MANUFACTURERS
OF THE UNITED STATES OF AMERICA,
New York, N.Y., May 2, 1960.

Senator CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR SENATOR ANDERSON: The Nuclear Energy Committee of the National Association of Manufacturers appreciates the opportunity to comment on the AEC report "The Future Role of the Atomic Energy Commission Laboratories."

As we have stated previously to you, it is our fundamental belief that in the area of civilian nuclear programs, Government-owned facilities should be used only for research and development activities requiring special facilities which do not exist in industry. Therefore, we were pleased to note that the AEC plans, as a matter of policy, to remove from their laboratories work which can be carried on by others. We believe this to be desirable regardless of whether the transfer is made to industrial facilities or to universities.

The Commission's overall objectives for the national laboratories are, from our point of view, highly commendable, but we have the feeling that the missions of certain of the laboratories are stated so broadly that their implementation might well result in controversy especially when the time comes to transfer functions outside of the laboratory. It would appear that the missions of the laboratories could be stated more precisely. This might serve not only to avoid possible future disagreements between the AEC and others, but also to improve the effectiveness of the individual laboratories. This general conclusion is ap-

plicable to several of the specific items outlined in Mr. Ramey's letter of March 11 and, for that reason, we will not make detailed comments on all of them.

We would, however, like to comment specifically on the Commission's intent to maintain personnel strength of weapons laboratories even if international disarmament agreements are reached. This we are strongly opposed to, since it smacks of a "make work" philosophy which is a wasteful and uneconomic one. We would certainly agree that maintenance of a strong weapons program is essential under the present world political situation, but if this situation should be markedly altered in the future, a reevaluation of laboratory goals and programs should be made at that time, with an obvious aim of monetary and personnel economies.

As I have said, the nuclear energy committee agrees with the overall objectives of the national laboratories, but we believe that there should be established some mechanism for a periodic review to determine how well these objectives are being met. To this end I have appointed a small group within the committee to study the best form such a mechanism might assume and to develop specific recommendations. Naturally this study will take some time, but you may expect to hear further from us when our recommendations have been formulated.

Sincerely yours,

L. M. CURRIE,
Chairman, Nuclear Energy Committee.

MANUFACTURING CHEMISTS' ASSOCIATION, INC.,
Washington, D.C., April 28, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I wish to thank you for giving the association an opportunity to review and comment on the report by the Atomic Energy Commission on the future role of their laboratories.

The report was read with much interest but I do not feel that, at present we are in a position to offer comments which would assist the Joint Committee in their review.

Sincerely,

J. E. HULL, *President.*

APPENDIX VII

COMMENTS RECEIVED FROM STATE AND FEDERAL AGENCIES

THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE,
Washington, May 9, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: Please excuse my delay in replying to your letter of March 14, 1960, pertaining to the AEC report on the future role of its laboratories, prepared for the Joint Committee on Atomic Energy.

I have read this report with considerable interest and regard it as an informative and useful study. Beyond this, I feel that it would not be appropriate for me to submit comments in more detail in view of the advisory, staff relationship of the Science Advisory Committee to the President.

Sincerely,

G. B. KISTIAKOWSKY, *Chairman.*

GENERAL ADVISORY COMMITTEE TO THE
U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., June 14, 1960.

MR. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C

DEAR MR. RAMEY: At the request of Gen. A. R. Luedecke, General Manager of the Atomic Energy Commission, the General Advisory Committee is glad to supply the following comments on the Commission's report: "The Future Role of the AEC Laboratories." After some general observations we shall comment upon the specific items of special interest to the Joint Committee.

I. GENERAL OBSERVATIONS

The General Advisory Committee and its Research Subcommittee were consulted by the AEC staff charged with drafting the above report from July 20, 1959, until it was in final form for presentation to the Joint Committee. After a number of informal conferences, the staff produced an initial draft which was given to the GAC Research Subcommittee for study and detailed comment. The comments of the subcommittee, as revised by the General Advisory Committee at its meeting October 28–30, 1959, were given to the Commission and the staff charged with preparing the report. The General Advisory Committee then had the opportunity of reviewing the report in essentially its final form at its meetings on February 1–3, 1960.

The staff preparing the report and the Commission welcomed the views and suggestions of the General Advisory Committee, and there was common agreement on most major policies and objectives. Although we may differ with some recommendations in the report in some of their details, we are in general agreement with the major recommendations. It is an excellent report, giving the best and most complete account of present activities, objectives, policies, and future plans of the AEC laboratories that has been prepared.

II. ITEMS OF SPECIAL INTEREST TO THE JOINT COMMITTEE

1. The future role of Commission laboratories by class (pp. 6–9, vol. 1)

We believe that the role of the AEC multiprogram laboratoris as stated in the report is soundly conceived. We wish especially to emphasize our opinion that each of these laboratories, in addition to carrying out the applied research and development projects assigned to them, should be engaged in programs of basic research and each should serve as a center for high cost research equipment such as accelerators and research reactors to be made available to university scientists and engineers on a national basis. The basic research programs which seem most important for the scientific staffs of multipurpose laboratories would seem to be in the following areas.

(1) Basic research related to development goals.

(2) Basic research projects requiring large capital investments and substantial teams of scientists and technicians.

(3) Basic research projects involving high operating costs, security restrictions, or health hazards.

(4) Basic research needed to make a laboratory an attractive place to a reasonable number of first rate scientists. This is important to the laboratories to keep them as imaginative and stimulating places and to maintain the interest and respect of university scientists.

We would not expect that the project engineering laboratories, with the exception of *Sandia*, would indefinitely have support from and be under the supervision of AEC. In the main these laboratories were established to accomplish specific applied research and development missions. It would appear that when these laboratories have accomplished their missions these installations would be either:

(1) Tranferred to other Government agencies or departments, or

(2) Transferred to industry, or

(3) Reduced in size and eventually discontinued.

We agree with the role outlined in the report for the production plant laboratories. Concerning the special purpose university laboratories, we recognize that the Argonne Cancer Research Hospital (University of Chicago) and the University of Rochester medical program are closely integrated with the medical schools of their universities, and therefore believe that in the long run it would be more appropriate for the support of these laboratories to come from the Department of Health, Education and Welfare.

2. Policies for Commission cooperation with universities and industry

We agree with the policies stated in the report concerning AEC cooperation with industries and with universities. We wish especially to emphasize the importance of effective cooperation between the AEC's multiprogram laboratories and the universities. Only in this way can facilities too expensive for individual universities be made available to university scientists and engineers, and this we deem essential for the future development of our universities and the education of an adequate number of scientists and engineers. Cooperation between these laboratories and university scientists and engineers will accomplish another important purpose; that of maintaining the laboratories as imaginative and stimulating centers for basic research and thus maintaining them as great national assets. In studying the history of laboratories supported by various Government departments and agencies, we find evidence that a laboratory which does not maintain contact with the universities and university scientists is not likely to remain an imaginative and stimulating center for basic research.

3. Research and development objectives of Commission laboratories

We believe the report outlines logical and worthy research and development objectives on a basis of present knowledge and what seems likely to be most important from the standpoint of our welfare and security in the future. It should be realized by everyone concerned that future events and presently unknown conditions might require substantial changes in research and development objectives.

4. Estimates of changes in work and level of effort in Commission research and development programs

We have no basis for making specific comments on the projected levels of support for the various Commission research and development projects. However we wish to make the following general comments:

(*a*) Development projects which are not urgent from the standpoint of military requirements or economic necessity and whose technical feasibility has not been demonstrated should be kept under fairly constant review, and support should be "cautious." In such projects large expenditures should not be made for "hardware" ahead of the proof of technical feasibility, economic analysis, and the possession of the necessary engineering materials. We refer here to such projects as thermonuclear energy production and manned nuclear powered aircraft.

(*b*) The Commission should be cognizant of scientific and engineering manpower needs in our total society. The AEC should not increase scientific and technical personnel on a project if such manpower is badly needed on other projects of higher priority for our welfare and security.

(*c*) Inasmuch as the capital expenditures and annual operation budgets in the support of high-energy physics are so large, and because research in this area in the long run probably must have more general national support, we believe that the basic research budget for this area should be separated from budgets for the support of other areas of basic research. Certainly no reasonable understanding of AEC's support for basic research in the universities and AEC laboratories can be obtained until the separation is made. Also, the expansion of high-energy physics in the country should not preclude badly needed expansion and support of the other areas of basic science.

5. Future facility addition and replacement plans at Commission laboratories

We agree fully with Commission plans to equip AEC laboratories, especially the multiprogram laboratories with the very best facilities for basic and applied research in nuclear science and technology. We refer to such facilities as accelerators, research, and materials testing reactors, etc. These are necessary if the United States is to stay in the forefront in nuclear science and its applications. Furthermore these facilities at the multiprogram laboratories should provide university scientists and engineers with research facilities beyond the capability of individual universities.

We believe it important to suggest that when such a facility is provided at an AEC multiprogram laboratory, the laboratory should not build its staff to fully utilize the new facility, but should expect university scientists and engineers to make substantial use of the facility. We believe the Commission should encourage and support university organizations formed to cooperate with AEC multiprogram laboratories, e.g., the Oak Ridge Institute for Nuclear Studies and Associated Midwest Universities.

6. Support of greater increases in basic physics and biomedical research at universities rather than at Commission laboratories

We agree with the proposed policy for the reasons given and also because it will help solve the critical problem of adequate numbers of scientists and engineers on university faculties in the next decade.

7. Maintaining the strength of weapon laboratories by expanding nonweapons work, if necessary

We agree with the policy statement. We would point out, however, that should the scientists in these laboratories be assigned to nonweapons research for a period of 10 to 20 years, we would no longer have capable standby weapons scientists. After such a period, one probably could organize more effective weapons research and development by bringing together able and vigorous younger scientists as was done in World War II.

8. (a) and (b) Size of and level of effort in Commission laboratories; planned changes in staff and program emphasis

The report sets forth general plans for the future activities of the Commission's laboratories which seem proper and in the national interest. We would be more inclined to restrict the size of the multiprogram laboratories than is indicated in the report. We believe that the effectiveness of the present laboratories can be improved better by emphasizing quality rather than size. This will involve among other things a careful review of personnel aimed at replacing those employees who are less effective. In all programs located at the multiprogram laboratories, continuous attention should be given to the elimination of those activities which are no longer productive or show little promise of becoming productive. As new assignments are accepted by a particular laboratory, some of the less productive older programs should be eliminated.

(c) Greater emphasis on more advanced nuclear research and development projects

We agree with the idea that the Commission laboratories in their applied research and development efforts should concentrate on advancing new concepts and developing new technologies. The more specific development projects based on concepts and technologies already available should be done under contract with appropriate industrial organizations. And the laboratories should not, of course, undertake any projects which industry is ready to carry out at its own risk and initiative.

(d) Should scientific personnel and facilities at Commission laboratories be utilized for nonnuclear research?

We see no lack of demanding and important research and development programs in the field of nuclear energy and believe that in the national interest, under present circumstances, the Commission's laboratories should therefore be kept fully occupied with nuclear research and development projects. However, there may be frequent and rapid changes in the character of the research and development which will be most important for our welfare and security. Therefore, should research and development in nonnuclear fields become for a time more important, the personnel and facilities of the Commission's laboratories should as needed be devoted to nonnuclear projects. The Commission's laboratories, especially the multiprogram laboratories, are important national assets and they should be doing what, at the time, best serves the National welfare and security.

We hope these views and comments of the General Advisory Committee will be helpful to the Joint Committee.

Sincerely yours,

WARREN C. JOHNSON, *Chairman.*

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., May 21, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I would like to thank you for giving us the opportunity to review and comment on the report entitled "The Future Role of the Atomic Energy Commission Laboratories."

Before commenting on the report let me say that, while the National Science Foundation collects and analyzes figures and information regarding research and development programs of the Federal Government as published annually in Federal Funds for Science, the mission of the Foundation, being the support of basic support and education in the sciences and policies related thereto, does not include applied research and development. Therefore, the Foundation has conducted no review of the activities at research centers such as the national laboratories of the Atomic Energy Commission. Our role has been confined to an awareness of the basic research conducted at such centers. Accordingly, our comments can only be general and concerned with the report itself and from considerations of the policy issues involved.

The report gives an excellent summary of the activities at the major AEC laboratories and of their future plans. Publication of this report will make a significant contribution toward effective coordination of research and development programs in fields related to nuclear energy.

In the overall system of Government laboratories, the Atomic Energy Commission has made particularly effective use of contractor operation of Government-owned laboratory facilities. It has been clearly demonstrated that this management technique can be adapted to the entire spectrum of research and development, from the most basic research to weapons development. This is both interesting and important since the management problem for the Federal Government as to whether and when to use the contract device or to establish a federally owned and operated laboratory has received considerable discussion and has not yet been clearly solved. This problem assumes larger proportions when contract-operated laboratories begin to take on a permanent character.

Of particular interest to the National Science Foundation is the problem of maintaining a close relationship between research at colleges and universities and research at major AEC laboratories. This is especially important in view

of the fact that many unique research tools, such as the new 30-Bev. proton synchroton at Brookhaven, are being located at the AEC laboratories. It is extremely important that the Commission continue its wise policy of making these instruments available to qualified user groups in academic institutions. This, too, has deep policy aspects in its relation to the progress of research and education throughout the country. Admittedly, a national facility for the conduct of scientific research and development may necessarily be a separate national research center because of the great size and cost of the installation. At the same time, it is well known that basic science in particular, generally speaking, thrives best where senior scientists are in close contact with graduate students. This takes place normally at universities where faculty members have formal courses or seminars of graduate instruction and when there is supervision of graduate theses in addition to the faculty members' own personal research. Thus, in the case of a national research center such as the AEC national laboratories it is most important for such a laboratory to maintain as close an association as possible with university graduate departments in its field of interest. This is admirably done in the present national laboratories of the Atomic Energy Commission. It should be borne in mind that in the case of research installations of lesser proportions, which can be more readily assimilated by universities, careful consideration should always be given to the establishment of such an installation in close association with a particular university. Incidentally, this latter point is one of considerable interest to the National Science Foundation and one where it is often important for the Foundation and the Atomic Energy Commission to confer in the case of proposed basic research installations.

In the important field of high-energy physics, as indicated in the report, the Atomic Energy Commission has taken a leading role in establishing and maintaining a strong national program. It should be noted, however, that this field is of such fundamental importance to science that its significance extends well beyond the specific responsibilities of the Commission for nuclear energy and weapons. Therefore, it is important that this field not be regarded solely as the special concern of the Commission. Major programs should be developed and supported by the National Science Foundation and other agencies such as the Department of Defense which have a substantial stake in the future of basic science.

Future plans for the laboratories contained in the report reflect an appreciation of the importance of basic research to the mission of the Commission. These plans also show a realization of the need to maintain program flexibility in the light of changes in technological needs and the state of our scientific knowledge.

All in all the report shows a careful and thoughtful consideration on the part of the Commission and the leaders in its scientific program which must be commended.

Sincerely yours,

ALAN T. WATERMAN, *Director.*

STATE OF CALIFORNIA,
GOVERNOR'S OFFICE,
Sacramento, April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: In accordance with the request in your letter of March 15, I am enclosing herewith my comments on the report, "The Future Role of Atomic Energy Commission Laboratories." For convenience I have numbered the items to correspond with the list of specific items attached to your letter.

Sincerely,

Col. ALEXANDER GRENDON,
Coordinator of Atomic Energy Development and Radiation Protection.

1. In item 2 on page 7, volume I, there is a proper emphasis on "the maintenance of a sustained effort in nuclear weapons technology." It is to be borne in mind throughout, as has been noted elsewhere in the report (see, for example, p. 67) that a decrease in this need may develop from efforts in the political scene. It is important for the economy of those geographical areas in which laboratories are situated that preparations be made for the transition to nonweapons applications as progress is made in the direction of reducing the pros-

pect of war. It is of importance also, as noted in the report, to insure that effective teams of scientists working in these areas of research are given suitable outlets for their talents.

On page 8, under "Project Engineering Laboratories," it is proposed that technical information developed on military programs will be made available for civilian use "to the maximum extent consistent with security interests." The importance of interpreting this restriction as liberally as possible, so as to release the maximum of information to encourage technological advances, can scarcely be overstated.

4. On page 51, it is stated that "an expansion of program is underway to study the effect of very low doses." This theme is elaborated elsewhere in the report. I have not noted, however, any recognition of an argument that has been advanced by some that, as a result of certain experiments on the lifespan effects of very low chronic doses, there is evidence that the lowest doses actually lengthen the lifespan. This is an aspect of radiation effect that must be firmly established one way or the other. Since those who hold that radiation hazards have been overestimated frequently base their claim on such studies, a large-scale experiment under the most rigorously controlled conditions, using numbers of animals sufficient to insure good statistical validity, seems essential in this regard.

The mention, on page 53, of studies in terrestrial and marine ecology concludes by stating that it will "require 6 to 8 years before these long-term programs can be in effective productivity." Because of the great importance of this type of information in evaluating problems related to the development of nuclear power, it would be desirable to get usable results at the earliest possible date. I am wondering whether additional funds placed in this program would materially reduce the time lag. If so, I would certainly urge such a step.

From the discussion, on page 56, of radiation detection instrumentation, I infer that there is no special interest in the development of a cheap, simple, mass-produced instrument for disaster use, whether of military or civil origin. The lack of such an instrument seems to me a serious deficiency in the civil defense program and may also be of great importance if wide dispersion of radioactive materials from a peacetime accident should occur. It is a key requirement that those in the affected areas should have some means of determining whether they are moving into danger or out of it.

6. I concur most heartily in the view that increasing basic physical and biomedical research in the universities to a greater extent than at the laboratories is a sound principle. In addition to the reasons advanced in the report, the broader geographical dispersion of such work would tend to develop many more nuclei around which these greatly needed skills can be developed.

8(*a*). Only in connection with the Oak Ridge National Laboratory work on page 96, do I see any specific mention of a study of waste disposal methods. This is an aspect of atomic energy development that has aroused so much public interest and, in most cases, antagonism that it is important to seek methods which will solve the problems in such a way as to remove this potential barrier to advances in this field. I would strongly urge that this topic be given great emphasis.

8(*d*). Since comment is solicited on "whether work in fields of nonnuclear research should also be performed which would utilize the scientific personnel and facilities at Commission laboratories," in my opinion such work should be limited to assisting scientists from other institutions who require occasional use of the facilities, equipment, and special services available at the Commission laboratories. It would seem appropriate for the laboratories' staffs to confine their own efforts to projects in which the interaction of atomic energy or radiation considerations with other fields is evident. I should think it probable that the most efficient use will be made of the laboratories' facilities if diversion into nonnuclear fields is kept at a minimum.

TULLAHOMA, TENN., *April 25, 1960.*

DEAR MR. RAMEY: I am unable to comment at length on the role of the AEC laboratories, because I am just recovering from a bout in the hospital.

The laboratories are absolutely vital to our national security and to our position in the atomic energy business. They should be kept strong and always out in front in this most important field.

Sincerely,

Maj. Gen. THOMAS F. FARRELL,
Power Authority of the State of New York.

DEPARTMENT OF THE INTERIOR,
BONNEVILLE POWER ADMINISTRATION,
Portland, Oreg., April 29, 1960.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: I appreciate receiving a copy of the Atomic Energy Commission's report to the Joint Committee on the future role of the Commission's laboratories. It is my view that these laboratories in general occupy an extremely important position in the scientific community of the United States. They have made outstanding contributions in the broad field of nuclear science, both from the standpoint of national defense and that of the peaceful applications of nuclear technology.

I support the view of the Commission that research and development work should increase significantly during the next decade. Emphasis, however, should be placed on those fields in which university and industrial laboratories are unable to perform adequately. The Commission's laboratories are vital not only to an adequate weapons development program but also to the achievement of economical nuclear power for industrial purposes and to the furthering of scientific education in this country, particularly in the postdoctoral category.

It seems to me especially important that advanced basic and applied research be stimulated and that the strong staffs now employed be maintained and strengthened in those fields where further work is indicated and where this work cannot adequately be done by independent educational and industrial laboratories.

The objectives and plans of the Commission for these laboratories seem constructive and reasonably adequate.

Sincerely yours,

E. C. STARR, *Chief Engineer.*

TENNESSEE VALLEY AUTHORITY,
OFFICE OF THE BOARD OF DIRECTORS,
Knoxville, Tenn., April 29, 1960.

Hon. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States, Washington, D.C.

DEAR MR. RAMEY: We appreciate the opportunity of reviewing the report to the Joint Committee on Atomic Energy on the future role of the Atomic Energy Commission laboratories. In accord with your request of March 15, 1960, for comments, we have some observations concerning the civilian nuclear power program.

We consider the long-range development of economic civilian reactors to be an important responsibility of the Federal Government. We believe that this should be recognized as a primary program objective, requiring the initiative and the vigorous leadership of the Atomic Energy Commission and its laboratories. This would seem to be an appropriate function for the AEC laboratories which, as is pointed out on page 4 of volume I, "comprise the principal portion of the Nation's existing competence in nuclear energy research and development." Therefore we would like to see a stronger and more specific statement of the program objectives relating to the cost and use of nuclear power. Item C on page 17 of volume I might be amended to read: "Conduct a vigorous long-range program to develop reactors capable of producing power at low cost in order to extend the benefits of economic power to all areas of the United States as early as possible."

This revision removes the uncertainty of such a mission as is implied in "support a continuing long-range program." It establishes as definite goals low-cost power and widespread use. We feel that cost reductions are likely to be achieved through sustained positive efforts and that significant economic benefits can come only through widespread utilization of nuclear power.

A detailed definition of the long-range nuclear power program is probably beyond the scope of your inquiry, but by way of illustration we suggest that the program should have the following features:

1. The objective would be to discover and develop technology specifically relevant to low-cost nuclear power. Although immediate applicability should not be a governing factor, emphasis should be placed on development within a reasonable time.

2. The staff directly responsible for planning and carrying out the program should not have other responsibilities that might claim prior attention.

3. The program staff should not be committed to any particular reactor concept, but should be expected to explore broadly, taking into account concepts and developmental results from all sources.

4. Conclusions resulting from preliminary explorations, analyses, and conceptual designs should be verified by experimental testing of crucial assumptions before commitments are made for large-scale development work.

5. Selections for further development should be based on the best available judgments of potentialities for technical feasibility and low overall power costs.

6. The experimental and analytical work should be paralleled by a program of engineering design and cost studies, in order to assure continued direction toward the goals of practicability and low cost. These studies should, of course, be no more elaborate than is justified by the corresponding state of technical development.

7. Program plans and schedules should be reconsidered periodically in relation to developmental results and rates of progress. The objective of such reviews should be effective redirection rather than diminution of the overall program effort.

8. The development of a low-cost fuel cycle and of fuel, coolant, and reactor materials that will be mutually compatible in the reactor environment should be given high priority. The solution of mechanical problems and the selection of heat-power cycles are less urgent, although they may eventually require much development work.

We have no comments on other sections of the report.

Sincerely yours,

HERBERT D. VOGEL, *Chairman.*

APPENDIX VIII

AEC REPLY TO THE U.S. CHAMBER OF COMMERCE, THE MANUFACTURING CHEMISTS' ASSOCIATION, INC., AND THE NATIONAL ASSOCIATION OF MANUFACTURERS CONCERNING POSSIBLE AREAS OF AEC COMPETITION WITH PRIVATE INDUSTRY

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., February 11, 1960.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR SENATOR ANDERSON: There is enclosed a copy of our reply to the letters received from the U.S. Chamber of Commerce, the National Association of Manufacturers, and the Manufacturing Chemists' Association regarding Commission implementation of Bureau of the Budget Bulletin 60–2. Copies of the associations' letters were previously sent you with our letter of December 18, 1959.

A public announcement on this matter is expected to be made in the near future.

Sincerely yours,

R. E. HOLLINGSWORTH,
Deputy General Manager.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., February 10, 1960.

CHAMBER OF COMMERCE OF THE UNITED STATES,
Committee on Commercial Uses of Atomic Energy
(Attention of Jack H. Abernathy, chairman).
NATIONAL ASSOCIATION OF MANUFACTURERS,
Nuclear Energy Committee
(Attention of J. F. Fairman, chairman).
MANUFACTURING CHEMISTS' ASSOCIATION, INC.,
(Attention of R. C. Johnson).

GENTLEMEN: Your letters which submitted examples of Commission activities which you believe may constitute competition with industry within the meaning of Budget Bulletin 60–2 cover to a great extent the same activities. For this reason, a single reply seems appropriate.

In carrying out its statutory responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise, the Commission has maintained a firm policy to procure goods and services from private industry wherever practical. From inception the Commission has turned to private industry to construct for the Government the major facilities required for the production of fissionable materials and for the comprehensive research and development program contemplated by the Atomic Energy Act. Government ownership of such facilities was found to be essential, since no reasonable way could be found to provide adequate incentives for private ownership of such specialized and costly facilities.

Further, as a means of utilizing and expanding the skills of the entire national economy and to take advantage of "know-how" and proven business experience,

the Commission engaged industrial companies and educational institutions to operate and manage these facilities.

The continued use of existing Government facilities is clearly necessary in the public interest for the production of fissionable materials, the assembly of weapons, and the conduct of most advanced research and development. The facilities and skills of private industry are and will be employed when they are adequate to carry out specific activities in the military and peaceful applications of atomic energy at the rate required to attain our national objectives. It should be emphasized, however, that the Commission must exercise care in discontinuing a specific activity to assure that related activities which are closely integrated do not unduly suffer in development, cost, or efficiency by reason of the divorcement.

In this new industry, the tempo of technological developments in many instances does not permit establishing precise specifications or assure a volume of repeat orders necessary to attract the investment of private capital in the specialized facilities, equipment, and personnel required. Consequently, there still remain areas of the Commission's work where it is premature to expect that such work can be procured from private industry on a competitive basis. Furthermore, we have a responsibility to avoid the concentration of services with a single source of supply, particularly under circumstances where such concentration might constitute a preemption of the market which would discourage widespread participation in the uses of atomic energy.

We recognize that as the atomic energy industry grows there will be areas of activity appropriate for transfer from Government to private operation. Numerous products and services formerly provided exclusively in Government facilities are now procured commercially, major examples being fabricated beryllium shapes, hafnium and zirconium products, uranium hexafluoride, and fuel elements for many nonproduction reactors. It is Commission policy to contract with private firms for the performance of title I and title II engineering of both nuclear and nonnuclear portions of the plant unless the nature of the work and the circumstances clearly dictate otherwise. Also, it is Commission policy, announced in 1956, that the Commission will cease to provide any service or product to the public whenever such service or product can be provided under reasonable terms by private industry.

The examples presented in your letters are concerned, in large measure, with specific activities within a production or research and development complex. Many of these activities have been carefully studied over a period of years for feasibility of separate contracting. A major reason for contracting with industrial concerns was to have our facilities operated in accordance with sound and proven business practices. Such business practices include procuring goods and services from specialized concerns wherever such concerns can satisfactorily furnish the product required and when to do so is sensible, economical, and consistent with the efficiency of integrated operations.

A typical example of the practices applied is contained in the following statement of policy of one of our major industrial contractors:

"The determination of the method by which these services will be performed is made in accordance with normal private industrial criteria, modified to the extent necessary to comply with existing AEC directives and applicable Federal law.

"These criteria include, but are not necessarily limited to, the following:

"1. *Costs.*—By what method and by whom can the service be performed at the least possible cost?

"2. *Relationship to the manufacturing process.*—How dependent is the process on the service being studied? Would an interruption in the service have a serious detrimental effect on the process?

"3. *Availability from commercial sources.*—Is the service available commercially at a competitive price? Is there sufficient productive capacity in commercial sources to assure delivery of needed quantities? Is the geographical location of the source or sources an advantage or disadvantage?

"4. *Volume of work.*—Is the volume sufficient to make it feasible for contracting?

"5. *Security requirements.*—What effect do the related security requirements, if any, have on the method of performing the service?

"6. *Developmental aspects.*—Is the design of the material or service sufficiently clear so that it is possible to contract without excessive cost?

"7. *Contamination.*—Is the material contaminated above limits which can be released to commercial sources?"

As applied to the Commission's operations, such typical business criteria are supplemented as applicable by other Government criteria such as those contained in the recent Budget Bulletin 60–2. Such supplementation provides, for example, that the elements of cost as provided for in Budget Bulletin 60–2 be considered in making comparisons between the cost of providing services at the Government-owned plant and the cost of procurement from commercial sources. Furthermore, our contractors are specifically advised of activities where it is Commission policy to subcontract to private industry. It is our practice to make surveys and appraisals of operations at Government-owned installations to review the continued application of these criteria. By effective application of such criteria, evidenced by thousands of contract actions annually for research, engineering, construction, equipment, and supplies, a wide range of enterprise in the atomic energy industry is being developed.

For each of the activities cited as examples in your letters, we have prepared comments which are attached. Many of the examples are in areas of future activities in which we look forward to either initial or increasingly greater industrial participation on a commercial basis, while others generally fall into the following categories:

1. Activities where industry is already engaged in the normal conduct of the work.
2. Activities which are closely integrated with plant operation and in accordance with accepted industry practice should remain integrated.
3. Activities which are in such a fundamental stage of development that the coordinated use of the skill and facilities at Government-owned installations is still required.
4. Activities where large volume is dependent upon military requirements and where extremely large plant investments have already been made by the Government, or where the volume of activity is so small, sporadic, and nonstandardized as to make it impractical or uneconomical to contract for separately.
5. Activities for which there is no known competitive commercial capacity.

We trust that this letter and our attached comments on the examples you have cited will provide a better understanding of the Commission's policy and practice regarding the utilization of private enterprise in fulfilling its responsibilities under the Atomic Energy Act. We will continue to examine commercial-industrial activities of the Commission in the light of the growing capability in the private atomic energy industry. For this purpose we will welcome at any time expressions from industry of their capability to provide additional services and products through ordinary business channels.

Sincerely yours,

JOHN F. FLOBERG, *Acting Chairman.*

ATTACHMENT TO THE COMMISSION'S REPLY TO THE CHAMBER OF COMMERCE OF THE UNITED STATES (C. OF C.), THE MANUFACTURING CHEMISTS' ASSOCIATION (MCA), AND THE NATIONAL ASSOCIATION OF MANUFACTURERS (NAM)

(Comments on AEC activities cited as examples of competition with industry within the scope of Bureau of the Budget Bulletin No. 60–2)

I. FUEL ELEMENT DEVELOPMENT AND FABRICATION

A vital part of any reactor is the fuel element with which it operates; the success or failure of a particular reactor experiment, prototype, or power reactor depends strongly upon whether a suitable fuel is available. Just what constitutes a suitable fuel depends upon the purpose of the experiment. Thus, in a zero power reactor the composition, weight, dimensions, and uniformity of the fuel are of controlling importance; resistance to irradiation damage is of very little interest. On the other hand, fuel for a high temperature, high burnup reactor must have a high degree of irradiation stability. Thus, the fuel must be tailored to fit the experiment. The fuel itself is experimental in nature. In the continuing effort to improve the fuel, successive loadings of the same experimental reactor are usually different, each type of loading being used only once. The Commission carries on an extensive program in the development of suitable fuel elements; this work includes the development of fuel and cladding materials, the determination of their physical, mechanical, and thermal properties, and their behavior under irradiation and thermal cycling, and development of methods of melting, casting, fabrication, and testing.

This program is so broad that it involves not only most of the Commission's laboratories and operating contractors but also a very large portion of the program is being conducted by commercial firms. In an action announced March 13, 1959, contracts with contemplated expenditures totaling over $25 million were awarded to 18 firms.

Outside of purely experimental tasks which must be closely coordinated with other development work, it is the Commission's general policy to obtain fuel element manufacturing services, other than for the production reactors at Hanford and Savannah River, from commercial sources. Our general policy is to procure reactor materials from commercial suppliers whenever adequate facilities, skills, and experience exist in commercial laboratories and the time schedule can be met. In addition, whenever it is feasible, we are now procuring end items containing nuclear materials rather than separately procuring materials and fabrication. The ability of industry to produce according to requirements has increased very appreciably in the last 5 years or so and more and more of the requirements are being met from industrial sources.

To illustrate the extent to which procurement from commercial sources has progressed, there follows a tabulation of the enriched uranium which has been furnished to all sources outside the weapon's production chain, showing the proportion furnished in the form of UF_6 compared to that furnished in a form requiring additional processing in AEC facilities:

Fiscal year	Total (kilograms)	Furnished in form other than UF_6		Furnished as UF_6	
		Kilograms	Percent of total	Kilograms	Percent of total
1958	45,000	21,000	47	24,000	53
1959	116,500	6,500	6	110,000	94
1960 (5 months through Nov. 30, 1959)	42,500	1,500	4	41,000	96

Comments on specific cases mentioned in the letters follow:

Experimental gas-cooled reactor

C. of C. VI–1: "Enriched uranium and/or pellets for the gas-cooled reactor project at the Oak Ridge National Laboratory."

MCA–5: "Enriched uranium oxide and/or pellets for the gas-cooled reactor project at ORNL."

NAM–A1b: "Supply of enriched uranium oxide, pellets, or metal for gas-cooled reactor project; * * *"

Oak Ridge National Laboratory (ORNL) is currently preparing the design and specifications for the fuel element and materials so that the core loading can be procured from industrial sources following normal procurement practices. In the development of this element, ORNL has attempted to procure from industrial sources enriched UO_2 and/or UO_2 pellets which meet its specifications. Experience to date has been disappointing in that ORNL has been unable to obtain the necessary quantities of acceptable materials. The yields have been disappointingly low, the schedules have had to be changed at the convenience of suppliers, and in all cases ORNL has obtained the pellets it required only by relaxing the specifications.

Process heat reactor

C. of C. I–2: "The conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Lomas, San Diego, Calif."

MCA–4: "Conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Lomas, San Diego, Calif."

NAM–A1a: "Conversion from UF_6 * * * for process heat reactor to be built at Point Lomas, Calif."

The invitation to reactor manufacturers to supply the reactor and certain primary system components included all of the internals and the reactor core with 14-percent spares. This invitation was issued in October 1959 and a number of proposals from manufacturers had been received and were being evaluated when the letters to which this reply is addressed were received. All of the fixed-price proposals received contemplate commercial supply of these

fuel elements by the selected proposer. The Commission is supplying UF_6; all other services will be obtained commercially.

Bulk shielding reactor and low-intensity test reactor

C. of C. I–1: "The Oak Ridge National Laboratory makes the fuel elements for most of its reactors. Examples include the bulk shielding reactor and the LITR."

Private sources of supply for procurement of replacement fuel elements for the LITR and BSR are not used for the following reasons: The demand for these elements, based on data accumulated during the past 5 years, indicates the following average yearly requirements: LITR, 15 elements; BSR, 5 elements. The number of replacement elements is low because of the low power at which these reactors operate. (The BSR operates from zero to 100 kilowatts and the LITR at 3 megawatts.) Since the BSR and LITR are used to test experimental fuel assemblies, about 25 percent of the replacement fuel elements are not standard. Dies and fixtures are available for these specific elements so that the small number required can be produced by laboratory staff as "fill in" work.

Materials testing reactor and engineering test reactor

MCA–7: "Supply of enriched uranium for ETR and MTR fuel elements."

NAM–A1b: "Supply of enriched uranium * * * metal for * * * ETR and MTR at Arco, Idaho * * *."

The original MTR fuel elements were fabricated at Oak Ridge prior to availability of commercial sources. The first MTR replacement also was the first core for an AEC reactor to be obtained from a commercial fabricator. Since then, all cores have been fabricated commercially:

MTR:
Replacement quantity 1[1], Babcock & Wilcox
Replacement quantity 2[1], Clevite
Replacement quantity 3[1], General Electric

ETR:
Original quantity, Babcock & Wilcox
Replacement quantity 1[1], General Electric

While the Government furnished metal in each of these cases, the statistics previously cited indicate the effectiveness of AEC's efforts to obtain the processing services from commercial sources. In the most recent case (MTR replacement No. 3) the invitation requested proposals on both bases (i.e., use of commercially procured metal or use of Government-furnished metal). The decision to use Government metal was based on the price differential analyzed in accordance with BOB Circular 57–7 (the predecessor to BOB Circular 60–2).

Nuclear rocket program, Project Rover

C. of C. I–3: "The conversion and fabrication of the fuel elements for the nuclear rocket program (Project Rover)."

MCA–6: "Conversion and fabrication of fuel elements for the AEC's nuclear rocket program at Livermore."

NAM–A1a: "Conversion from UF_6 and fabrication of fuel elements for AEC nuclear rocket program at Livermore; * * *."

Responsibility for all research and development for the nuclear propulsion of rockets (Project Rover) is assigned to the Los Alamos Scientific Laboratory. Enriched uranium metal for Rover fuel elements is drawn from the inventory maintained at Los Alamos for the weapons program, and fuel element fabrication work is performed in the same facility in which development of uranium fabrication techniques is carried on for the weapons program. The material for Rover is a relatively small proportion of the amount fabricated in that facility.

At present, every Rover reactor is different. Fuel element requirements and technology are still in development, and cannot yet be described by definite and inclusive specifications. In view of the frequent and last-minute changes in design details and characteristics to be sought, fuel element fabrication for the current, research-type Rover systems must continue as an activity performed directly by the Los Alamos Scientific Laboratory.

At later stages when there are repetitive tests of a single design, the degree of standardization may permit commercial procurement of both the conversion and fabrication of uranium for Rover fuel elements.

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[1] One year's supply.

Naval reactors

C. of C. III–1: "Conversion of enriched * * * uranium from UF_6 as required in the 'nuclear navy' for metal, alloys, or uranium compounds."

MCA–1: "Conversion of all enriched uranium from UF_6 as required in the 'nuclear navy' for metal, alloys, or uranium compounds."

NAM–A1b: "Supply of * * * all uranium alloys or compounds for the 'nuclear navy'."

Practically all of the highly enriched uranium utilized in these cores is obtained from scrap metal in the form of trimmings left from material utilized in the weapons program. These trimmings are chopped into small pieces and shipped to the core manufacturer who performs all further processing and fabrication operations involved in the manufacture of the fuel elements.

There are now five private companies supplying reactor cores for the naval reactors program on a fixed price, competitive basis. Through calendar year 1959, contracts totaling approximately $200 million have been awarded to private industry for fuel fabrication.

These companies now manufacture all reactor cores for the naval reactors program with the exception of some first reactor cores of a type which are of a highly developmental nature. However, many of the parts, even for these first developmental cores, are manufactured by private industry rather than in the Commission's Bettis and Knolls Atomic Power Laboratories. In this connection, it is also significant that a substantial portion of these parts for developmental cores which are subcontracted to private industry are in themselves of a developmental nature. This type of subcontracting from the Bettis and Knolls Atomic Power Laboratories to private industry has been increasing, commensurate with industry's capability to handle such work. Thus, the fuel fabrication work that remains in these Laboratories is only that which is of a highly developmental nature and pertains specifically to the first core of a new design being developed at the Laboratory.

Subcritical training reactors

MCA–12: "Conversion and fabrication of uranium elements required for subcritical training reactors for educational institutions."

NAM-A1a.: "Conversion from UF_6 and fabrication of fuel elements * * * for subcritical training reactors * * *."

Educational institutions, as of January 1960, possess or are planning to acquire two enriched uranium and 84 natural uranium subcritical training reactors. The fuel is furnished by the AEC without charge to the institutions. The enriched fuel is fabricated commercially and the natural uranium fuel is furnished by the AEC from its supply of reject slugs at Savannah River. It is anticipated that in the next several years educational institutions will require approximately 25 new subcriticals per year.

Since these are vital to the educational programs on which both industry and Government must rely for new trainees for this expanding industry, it is desirable to provide the facilities so that the greatest number of training programs can benefit. Use of material which does not meet the production reactor specifications is a suitable and economical means of increasing the effectiveness of the training program.

Nuclear ramjet project

C. of C. VI–2: "Enriched uranium for the nuclear ramjet project."

On the original order for fuel for the Tory II A, the conversion from UF_6 to U_3O_8 was performed by the Commission's Oak Ridge Y–12 plant. Y–12 was used for this job on the basis of a technical evaluation of capability. Because of the unique and stringent chemical specifications for the U_3O_8 it was determined that no source other than the highly experienced Y–12 plant could be reasonably expected to perform this conversion job on the required schedule and at an acceptable cost. It is anticipated that future requirements for conversion of UF_6 and the fabrication into fuel materials will be obtained commercially, providing that commercial capability exists to provide these services at reasonable cost and upon the required schedules.

Piqua and Hallam reactors

MCA–13: "Production of enriched uranium metal for the Piqua and Hallam reactors."

Present plans for both the Piqua and Hallam reactor projects are that the fuel conversion will be done commercially. Fabrication in both cases will be

by Atomics International, the AEC prime contractor for construction of the reactor. In both cases arrangements have not yet been completed.

Heavy water components test reactor

MCA–11: "Production of uranium for heavy water component test reactor being built at Savannah River."

C. of C. I–4: "Savannah River is also doing fuel element development work. This includes the conversion and fabrication of fuel elements for the fuel element heavy water test reactor being built at Savannah River."

NAM-Ala.: "Conversion from UF_6 and fabrication of fuel elements for heavy water components test reactor at Savannah River."

The driver and fuel elements for the heavy water components test reactor are not being manufactured at the Savannah River plant. This work is being carried out in commercial facilities, Nuclear Metals, Inc., Concord, Mass., under a du Pont subcontract. The contract for this work was awarded after a survey of six fuel element manufacturing concerns which appeared to have the experience and facilities for making tubular metallic fuel elements. In the case of the driver tubes, the small number required resulted in little interest by industry in this operation. It was indicated, however, that should significantly larger numbers of tubes be required, industry would be interested in submitting bids. In the case of the heavy water components test reactor fuel elements, these are still in the development stage. Considerable development work and testing are required before establishing a firm design for this element. Nuclear Metals has been engaged to do much of the development work and to supply the necessary test elements during the development period.

Savannah River and Hanford production reactors

C. of C. I–4: "The Savannah River site makes some fuel elements for its reactors. Savannah River is also doing fuel element development work."

C. of C. I–5: "Fuel elements for the Hanford site are fabricated in Government facilities."

The manufacture of fuel elements for production reactors has been accomplished in Government-owned facilities operated by industrial contractors since the initiation of production activities during World War II. As the AEC program expanded, additional capability was provided to meet the increased requirements. The current operating facilities at Fernald and Weldon Spring represent a Government investment of about $165 million. These facilities are operated by industrial companies under cost type contracts.

There is no privately owned industrial facility in being which can meet the requirements of the production program. It is not considered feasible to contract for production reactor fuel element fabrication in privately owned facilities at fixed prices, chiefly because of the frequent and substantial changes which are required in fuel element types, specifications, and quantities resulting from new conditions in the production reactors. The operation of fuel fabrication plants must be closely integrated with production reactor operations and thereby with weapons production schedules. In order to accommodate new operating requirements without delay, any fixed price arrangement with a private supplier would necessarily involve price renegotiation to offset changes in costs as requirements change. Such an arrangement would approach closely a cost-type contract similar to those which now exist between the companies operating AEC's fuel fabrication facilities and the AEC.

Because the level of production is directly related to weapons requirements and reactor performance both of which are subject to substantial change on short notice, because it is difficult to set firm specifications, because civilian requirements are so low that this capacity could not be fully utilized for peaceful purposes for many years, and because of the large investment already made in AEC plants, the establishment of duplicate fabrication facilities by industry would not be in the best interests of either the Government or industry.

New production reactor

C. of C. VI–3: "Enriched uranium metal and/or fabrication for the new Hanford production reactor."

MCA–8: "Enriched uranium metal and fabrication of fuel for the NPR at Hanford."

NAM–A–1–b: "Supply of enriched uranium * * * metal for * * * NPR at Hanford * * *."

The new Hanford production reactor, which is being built on an accelerated time schedule, will use metallic uranium fuel elements under temperature conditions similar to those which are found in current power reactors. This operating condition, representing a substantial departure from other AEC production reactors, requires that an extensive fuel element process development program be conducted to develop specifications and fabrication and testing techniques. This work is being performed concurrently with the design and construction of the reactor. To avoid delay in startup of the new reactor, the installation of the fabrication facilities must also proceed concurrently with the construction of the reactor, even though firm specifications are not available. Since even process specifications are not firm, and would be subject to change as operating experience is gained, contracting with industry for these fuel elements at this time could only result in the AEC's entering into a cost type contract for the operation, similar to those now in effect between AEC and the contractors operating plants. Since the AEC already has in existence or will install for the development program much of the equipment required to process the uranium and fabricate the proposed type of fuel elements, the incremental AEC investment required will not be major.

However, since industry has indicated possible interest and capability for performing these operations, arrangements have been made for an industrial group to review the question of production of NPR fuel elements in private facilities. Their report has now been received but the Commission has not had an opportunity to evaluate its recommendations.

II. REACTOR DESIGN AND DEVELOPMENT

General

NAM–C–1–d: "Design, construction, and testing of reactors, reactor prototypes, and reactor experiments for which industrial capacity and capital exists."

Research, development, and experimentation in the general field of advanced reactor development by AEC laboratories is a prime responsibility of such installations. The chamber of commerce letter itself recognizes this role of the AEC in section VIII of its letter. The design of an advanced reactor cannot in reality be divorced from the development effort leading up to the actual prototype reactor itself.

To the maximum extent consistent with the paramount objective of obtaining the desired technical data for which it is necessary to build a prototype of a particular reactor type, it is the intention of the Commission to construct prototype plants under cooperative arrangements with utilities, public or private. It is highly desirable to have power reactor prototypes integrated into power systems to secure information on compatibility and performance and on maintenance and operation. The Commission plans to construct such facilities on its own sites only if responses to invitations are not received or are not acceptable. All power reactor prototypes constructed by the Commission, whether at a utility or Commission site, are designed and constructed under contract by private companies with the Commission generally specifying only the reactor conceptual design, approximate power size, and general objectives, plus such specific parameters as are necessary to assure obtaining the information which the reactor is intended to provide.

With respect to experimental reactors and reactor experiments, these are for the most part designed by Commission laboratories, with that portion of the design which is not a direct outgrowth of the experimental program being furnished by architect-engineers. Among the more important reasons for assigning to the laboratories the primary responsibility for such projects are: (1) they are generally merely an extension of a planned laboratory program and as such, are of more benefit when designed, operated, and altered, as needed to accomplish the project objective, by the laboratory personnel; (2) due to the experimental nature of the project, specifications are developed as the work proceeds and a complete set of specifications is not available for the solicitation of bids from industry; (3) in many cases, the experiments are merely modifications of previous experiments; and (4) ancillary equipment already existing at Commission sites can be used which reduces the cost of the project and the time and effort required for setting up the experiment.

Detailed comments are given below and, in general, these comments are applicable to the general design, construction, and testing of AEC reactors. Current policy is that conceptual design will be made by the best qualified organ-

ization. However, title I and title II type work is normally contracted for with engineering firms.

Oak Ridge research reactor

C. of C. II–3: "Oak Ridge National Laboratory's title I and title II design of ORR."

The Oak Ridge National Laboratory had responsibility for the design of the ORR. However, titles I and II design services required for this facility were by no means accomplished exclusive by members of the ORNL engineering staff. A private organization—the McPherson Co. of Greenville, S.C.—performed a significant amount of the title II design work. The McPherson Co. participation in the design of the ORR included the design and preparation of working drawings and specifications for the complete reactor building, building services, utilities, reactor shield, reactor pool, and reactor cooling system. Oak Ridge National Laboratory, as the Commission's operating contractor, had direct responsibility for initiating and developing the overall concept for the facility, for the preparation of design criteria for all phases of the project, and for the definitive design of the reactor proper including instrumentation and controls.

The latest figures on total cost of the ORR show that less than 6 percent was expended by Oak Ridge National Laboratory engineering forces on design which could be considered as title I or title II engineering. Approximately one-third of the 6 percent was expended in preliminary work required to develop design criteria and specifications necessary for the design work to proceed. The remaining 4 percent was expended in coordination of the work with the architect-engineer and in design of the reactor proper and the reactor control system.

High-flux isotope reactor

C. of C. II–1: "Oak Ridge National Laboratory's design of a high-flux isotope producing reactor."

It is anticipated that all title I and title II design of all portions of this job will be performed by an architect-engineer except for the design of the core and control systems. All control system components will be purchased from industry. Those portions of the job to be designed by an architect-engineer are a major fraction of the project.

The performance of this reactor will exceed by a large factor the performance of any existing reactor and is higher by a factor of nearly 2 than any other proposed high-flux reactor. It represents a sizable extrapolation of existing technology. In order to accomplish the research aims of the reactor it is necessary to advance the limits of current technology. We believe it to be the purpose of our national laboratories to perform this type of development.

Beam research reactor

C. of C. II–2: "Brookhaven National Laboratory's preliminary design of the beam research reactor."

The high-flux beam reactor will be used principally for research projects that require external beams of neutrons at both thermal and epithermal energies. The conceptual design study of a new and advanced research reactor was largely an effort to develop the best compromise of the needs of the experimentors, the actual performance of a chosen fuel and moderator array as determined by critical experiments, and engineering considerations of cost, safety, and general feasibility. Even on this conceptual study Brookhaven was assisted by an industrial company, and in July 1959 statements of interest concerning all phases of the design, equipment procurement, and management of construction of the reactor were solicited from 12 industrial companies. Nine proposals were subsequently received and we are currently negotiating with one of the companies for this work.

Sandia test reactor

C. of C. II–5: "Sandia and Los Alamos design work for the Sandia test reactor."

As of December 31, 1959, this facility was 31 percent complete and is expected to go critical in late 1960.

All design aspects of the building and practically all design aspects of the reactor and associated equipment were handled through contracts with outside concerns. The designs of the reactor and associated equipment were based almost entirely on other components and fuel elements already in existence and involved only minor design modifications. The total design effort for the reactor

and associated equipment was covered by approximately $75,000 in outside design contracts plus approximately 4 man-years of combined Sandia and Los Alamos time over a 3-year period. The Sandia-Los Alamos effort in this area was the minimum necessary to keep Sandia personnel sufficiently knowledgeable to insure that it would get what it needed to do its job and to provide a background for the operation of the reactor.

Process heat reactor

C. of C. II–7: "Argonne National Laboratory's title I design of the process heat reactor."

The ANL made an evaluation study of those reactor concepts which are proven to see if any such concept is particularly suitable for this application. The AEC also requested the Laboratory to provide a report on the conceptual design for the selected reactor concept and an outline for the research and development program for such a reactor. The title I design of the process heat reactor was not performed by Argonne but by Sargent & Lundy.

Natural circulation reactor

C. of C. II–8: "Knolls Atomic Power Laboratory's work on a natural circulation reactor for the Navy."

The development of a reactor plant for naval operation is quite different in many respects from the development of a stationary reactor plant. The compactness of the reactor system, the high power density, the shock and vibration requirements, the maneuvering capabilities, and the operation of the plant under varying conditions of inclination give rise to problems not encountered in a land plant. The natural circulation reactor plant is a new concept for naval application and its successful and timely completion as well as its further advancement requires full exploitation of pertinent naval reactor technology. The Commission laboratories which have specialized in naval research and development work for about 10 years are, to our knowledge, the only organizations having the necessary technical talent, experience, and special facilities for undertaking this project in the most expeditious manner.

Army low-power reactor

C. of C. II–11: "Argonne National Laboratory's development of the Army low-power reactor."

NAM–C–1–e: "The first reactor in the Army low-power reactor program was fabricated by an industrial concern at its own facilities, but the second will be fabricated in a Government-owned facility."

We assume that the SM–1 plant at Fort Belvoir is the first reactor and the SL–1 (formerly ALPR) at the National Reactor Testing Station is the second.

In the light of a known interest of the Department of Defense in a nuclear powerplant of approximately one-tenth the capacity of the SM–1 at Fort Belvoir, six separate reactor concepts were investigated to determine which could best meet the requirements of the Department of Defense. These studies were made between January and June 1955. Of the various systems investigated, the boiling water system study by the Argonne National Laboratory appeared to be most suitable for this purpose.

Inasmuch as there was no industrial experience with power reactor systems developed at that time, Argonne was requested to undertake development and construction of the prototype 200–300 k.w.-e. plant which the Department of Defense requested in September 1955. In the course of constructing this plant, Argonne used subcontracts with many industrial firms. An industrial firm was awarded a contract to fabricate the fuel elements but defaulted because it was unable to fabricate elements meeting the prescribed standards. In order that the project completion date would not be jeopardized, the fabrication of the core was undertaken by Argonne Laboratory. Since completion the plant has been operated by Combustion Engineering.

III. THORIUM

C. of C. VI–8: "Supplying AEC's needs for thorium alloy, thorium oxide, thorium carbide * * *."

MCA–14: "Supply of thorium oxide for the homogeneous development program at ORNL."

MCA–15: "Supply of thorium metal for special projects at Los Alamos, Sandia, and Lawrence Radiation Laboratory at Livermore."

NAM–C–1–a: "Supply of thorium oxide for homogeneous reactor development at ORNL."

NAM–C–1–b: "Supply of thorium metal for special projects at Los Alamos, Sandia, Lawrence Radiation Laboratory at Livermore."

The AEC presently has no production capacity either operating or available for the processing of thorium to metal. A small pilot plant for preparation of special types of thorium oxide powders is in operation at ORNL. Several years ago a thorium metal pilot plant was built at Fernald site and operated for a short period. Since the anticipated requirements for thorium which were the basis for the Fernald pilot plant effort did not materialize, the facility was shut down in 1955 and has been dismantled. During its period of operation, the plant produced a small inventory of thorium metal and compounds from which the small needs which have developed since 1955 have been supplied. It is intended that future requirements of comparable size would continue to be supplied from this inventory as long as available. The ORNL pilot plant, on the other hand, is preparing thorium oxide powders in an effort to produce oxide having desirable slurry properties for use in the homogeneous reactor program. Oak Ridge has also procured sample quantities of oxide from industry for testing. Development work on preparation of acceptable powders supported by AEC funds has been carried out by ORNL and several private companies. The development program at ORNL is still underway. At such time as an oxide has been developed having the desired slurry properties for which a specification can be set, we would seek to obtain thorium oxide for use in homogeneous reactors from commercial sources.

Current thorium operations are limited to development efforts on the utilization of this element in AEC programs. There are some indications that there may be a continuing requirement for modest quantities of thorium metal which would exceed the current inventory. Should such develop, AEC will obtain the metal by procurement from commercial sources.

IV. DESIGN OF FACILITIES AND EQUIPMENT

Hot cells at Argonne National Laboratory

C. of C. II–4: "Argonne National Laboratory's title 1 and title 2 design of hot cells for its new research laboratory."

It is assumed that reference is made to the hot cell area in wing F of the Fuels Technology Center, now under construction. The title I and title II designs of the building were carried out completely by a private architect-engineer (Singmaster and Breyer) on the basis of preliminary designs prepared by Argonne. The design of the manipulator, windows, and internal cave hardware is being carried out by Argonne because of the experimental nature of the design concept. In this particular case the cave equipment is being designed so that the operations can be carried out for extended periods of time without the need for access by personnel. The design concept represents a complete departure from present operating techniques and requires a large advancement in all aspects of remote handling equipment. This new research metallurgy facility must be gastight to contain an inert atmosphere. No existing type of master slave manipulator is designed to operate under these conditions. Although the need for this new approach to remote handling has been discussed in open forums, no commercial company is working on this problem to the best of our knowledge.

It was also felt that the design of these features should be carried out by scientists and engineers who have already used such facilities and are acquainted with other problems in the design of remote handling and viewing systems.

Nuclear ramjet engines

C. of C. II–6: "The Government's University of California Radiation Laboratory's design, test, and fabrication of nuclear ramjet engines."

The function of this program is to determine the feasibility of and construct a nuclear reactor as a ramjet engine and does not include design, test, and fabrication of nuclear ramjet engines on a production basis. The Laboratory is subcontracting as much of this project as is feasible, considering the technical requirements and schedules involved. Subcontracts with industry currently amount to about 45 percent of the Laboratory's budget for the project.

Thermionic cells

C. of C. II–9: "Los Alamos' experimental work on thermionic cells to convert fission energy directly to electricity."

This item refers to the "plasma thermocouple," a present research project at the Los Alamos Scientific Laboratory. As far as we are aware, the basic idea originated at LASL where technology in the exotic materials involved (uranium and zirconium carbide), scientific competence, and adequate laboratory facilities required are available.

This field of research is unclassified and completely open to industry. The AEC welcomes parallel research by industry and the publication of the results of such research. LASL has published numerous documents in this area and has briefed many industrial organizations upon their work. We encourage our laboratories to undertake frontier research of this nature.

V. DEPLETED URANIUM

C. of C. III–1: "Conversion of depleted uranium from UF_6 as required in the 'nuclear Navy' for metal, alloys or uranium compounds."

C. of C. III–2: "Depleted uranium metal for an AEC shielding cask project at Schenectady."

MCA–2: "Depleted uranium for all activities at the national laboratories with specific atention directed to the conversion of depleted uranium from UF_6 and the fabrication of blanket fuel elements for the zero power reactor at Argonne National Laboratory."

MCA–3: "Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field representing aproximately 40 tons of cylindrical casting."

MCA–9: "Depleted uranium metal for AEC shielding cask at General Electric, Schenectady."

NAM–A2a: "Supply of blanket fuel elements for zero power reactor at Argonne National Laboratory."

NAM–A2b: "Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field."

NAM–A2c: "Suply of depleted metal for shielding cask project at Schenectady."

Depleted uranium metal is used to a very limited extent in the naval reactors program as a shielding material in certain refueling equipment where compactness is required. Specifically, it has been used in the refueling equipment for the S3G and A1W type reactor plants. The depleted uranium for this equipment was fabricated into the desired shapes at Oak Ridge. The events leading to the decision to do the work at an AEC facility can be summarized as follows: In 1957, representatives from 11 private industrial concerns were invited to a prebid conference called to determine whether commercial vendors were technically capable of fabricating the depleted uranium shielding components for the S3G refueling machine developed and being manufactured by the United Shoe Machinery Corp. Three companies responded. As a result of this conference, the decision was made to perform the fabrication work at Oak Ridge because the capability of the three interested commercial vendors was uncertain, whereas it was evident that Oak Ridge had an established capability to perform this work. All three of the interested vendors lacked experience in casting the required depleted uranium alloy, and it was questionable whether their facilities could handle the size of the castings required. Similarly, starting in 1956, the United Shoe Machinery Corp. designed and developed for the Bettis Laboratory a maintenance and refueling machine for use with the A1W type 1 and 2 reactor cores. Depleted uranium for this machine was also procured from Oak Ridge.

It is probable that the questions concerning the ZPR refer to the ZPR–VI and IX blanket for which procurement was initiated in November 1959. (The last procurement for ZPR–III was in 1957–58.) Bids were requested for conversion of UF_6 to metal and commercial suppliers have been selected for both conversion and fabrication steps.

In another case, that of the EBR II blanket material, an exception was made to the general policy of using commercially available facilities, based on the apparent price differential that existed.

VI. IRRADIATION SERVICES

C. of C. V: "Preference should be accorded private irradiation facilities in place of the current preference for loading Government facilities first. This is the best way of encouraging more private capacity. Underloaded commercial facilities exist whereas it is our impression that the Government-owned facilities are heavily loaded. AEC's practice of offering space in the Government-owned MTR and ETR should be limited to only those specific cases where private facilities are unavailable."

NAM–B: "The AEC should announce a policy to utilize privately owned reactors for materials testing to the extent that industry is able to provide space. This use of private reactors should be in preference to the use of a similar Government-owned facility. The current use of MTR and ETR for Government-sponsored research, which constitutes the great majority of the materials testing business, results in severe competition for the private test reactors."

Negotiations currently are underway to determine the extent to which irradiation services required for Commission programs can be obtained from either the Westinghouse or General Electric test reactors. As announced last summer, negotiations are also being conducted with the Babcock & Wilcox Co. for the construction of an additional test reactor. Irradiations will be continued at Commission test reactors depending upon the type of irradiation required and the cost of outside service.

VII. CHEMICAL PROCESSING

Cold uranium scrap

C. of C. VI–7: "Chemical processing of cold industrial scrap."

MCA–16: "Recovery of cold fabrication scrap, both high and low enriched, from all of the above projects."

In early 1959, AEC took the initial steps to acquire more scrap recovery services from industry. In March 1959, AEC began to send bid invitations to commercial scrap recovery firms to provide this service. On November 4, 1959, AEC assigned the responsibility for developing the domestic unirradiated uranium scrap industry to New York operations office. That office is acting as a central point for the AEC and its contractors for the placement and administration of contracts for commercial recovery of uranium scrap generated under the reactor development program. From March through November 1959 approximately 11 awards were made aggregating 344 kilograms of uranium with a total of $180,200 for recovery charges.

The New York operations office is currently establishing a system whereby the scrap available for commercial recovery will be reported by other offices and invitations for bids will be solicited from private firms. As a result of these steps it is expected that the commercial recovery of cold scrap will grow substantially in the future.

Irradiated fuel elements

C. of C. VII: "It is recognized that the reprocessing of irradiated fuel elements represents an area that is difficult to assess commercially. However, there is no reason to believe that many chemical firms could not handle the job if pricing, regulatory, and load problems could be successfully met. While the Government is spending large sums on developing new processes which inhibit industrial investment in known processes it can speed the transition toward a desirable commercial mode of operation by making maximum use of industrial firms in research and development and possibly the construction and operation of reprocessing plants."

NAM–A–3: "In the area of reprocessing of irradiated fuel elements, the Government can and should greatly aid in the transition to a commercial mode of operation by making maximum use of industrial groups in process research and development and in construction of, and operations related to, reprocessing plants. To promote the growth of a healthy industry in this area, Government funds should be used to finance research and development programs in privately owned facilities in preference to Government-owned facilities.

The Commission has made a continuing effort to bring private industry into the field of chemical reprocessing of irradiated fuel elements. At the present time, a group of five electric utilities and a chemical company are studying the technical and economic feasibility of the design, construction, and operation of a privately owned facility for the processing of spent nuclear fuels. This study will take approximately 6 months, at the end of which time it is expected that

industry will have a much clearer view as to the potential in this field. The study has the full support of the AEC. Other groups making similar studies would have the same AEC support.

Since there are a number of approaches to the problem of private operation in this field, and technology must be developed in order to find a satisfactory solution to the general problem, development programs must proceed consistent with the objective of obtaining economic nuclear power. AEC believes that the absence of adequate technology necessitates the continuation of its programs.

Although to our knowledge there are no facilities outside of AEC capable of undertaking major development programs on recovery of spent fuel elements, AEC is prepared to receive proposals for research and development to improve fuel recovery technology.

VIII. INSTRUMENT DEVELOPMENT AND MANUFACTURING

C. of C. II–10: "Oak Ridge National Laboratory's Instrument Development Section which in some instances is working on the development of instruments in competition with commercially available equipment."

C. of C. II–12: "Each of the major Government projects have developed their own, and different: hand-and-foot monitors, scalers, survey meters, and multichannel radiation analyzers in competition with commercially available equipment."

C. of C. VI–6: "Instrument production work at Los Alamos, Oak Ridge, and the University of California (Berkeley)."

NAM C1g: "Personnel radiation monitors are developed and produced in instrument production sections at Government-owned laboratories. There is an instrument industry capable of furnishing such monitors and it should be used."

NAM C1h: "Government construction of radiation measuring equipment is also in direct competition with the private instrument industry."

It is the express policy of all of the laboratories to procure instruments which are available commercially rather than to fabricate them. A survey of all laboratories and industrial establishments made in 1954 showed that over 80 percent of radiation instruments of all types were procured from private industry. A more recent survey indicates this percentage ranges from 90 percent to 100 percent depending upon the mission of the facility.

It is true that some instrument development work is continuing at major laboratories. Such work is necessary for the following reasons:

(*a*) To modify or create instruments to meet the specific requirements of a research project where the time and engineering effort necessary to prepare specifications, issue bids, instruct outside personnel, inspect for precision, and return for corrections, make outside procurement impractical;

(*b*) To develop designs in instances where commercially available instruments have proven unsatisfactory in performance and private companies have not improved their products on their own initiative but will adopt laboratory developed designs.

While it may appear that each laboratory develops its own instruments, our survey indicates that such development is undertaken only when necessary to meet a particular condition for which a commercially available instrument is not adaptable. The facts in respect to specific instruments are:

(*a*) *Hand-and-foot monitors.*—Obtain commercially. Developed initially by the laboratories. One laboratory has recently developed an improved design for greater reliability.

(*b*) *Scalers.*—Such instruments typically must be modified to meet specific needs. The laboratories use commercial subassemblies.

(*c*) *Survey meters.*—While these meters are purchased from private industry, the laboratories have had to undertake development of more reliable designs in the absence of such development by industry.

(*d*) *Multichannel analyzers.*—To our knowledge, the only development work on these devices is that necessary to achieve devices for special applications. As an example, one laboratory assembled one such device in calendar year 1959 at a cost of $12,000 while in the same year it procured $192,000 worth of such devices commercially.

IX. PRODUCTION OF RADIOISOTOPES

Cobalt 60 for the High Intensity Radiation Development Laboratory

C. of C. VI–4: "Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

MCA–10: "Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

NAM C1c: "Supply of high purity cobalt for High Intensity Radiation Development Laboratory, Brookhaven."

The high purity cobalt in the form of nickel-plated targets for the Brookhaven radiation development facility was furnished commercially. All such cobalt is and has been supplied by commercial vendors to AEC. The canning of the cobalt for use in a reactor is controlled by the reactor operator to insure the safety and integrity of all material inserted into the reactor. Approximately 500,000 curies of cobalt 60 are needed for the Brookhaven National Laboratory program and are being produced in the engineering test reactor. At the time the radiation was begun no commercial sources of cobalt 60 existed.

Production of certain radioisotopes

C. of C. IV: "The Government is currently producing certain radioactive isotopes in a commercial way (e.g. cobalt 60, iodine 131, carbon 14, sulfur 35, phosphorus 32). The demand for these radioactive isotopes is now at a level which makes commercial production feasible and commercial facilities exist which should be utilized."

C. of C. VI–8: "Supplying AEC's needs for * * * high purity cobalt and radioisotopes."

AEC's needs for radioisotopes are small in relation to AEC sales to others, representing 14 percent of the dollar sales. Until such time as commercial producers can supply the requirements, AEC production of radioisotopes will be necessary to meet all or part of its own needs. Commercial production of radioisotopes is small at the present time except for cobalt 60.

The Government is producing some, but not all, radioisotopes in a commercial way. In 1955, AEC discontinued the production of cyclotron produced radioisotopes because commercial sources were in a position to produce and market these products at reasonable prices. Also, many of the radioisotopes currently distributed by AEC are produced on a laboratory or semiworks scale because of the small demand, principally for research and developmental uses.

The AEC has never competed with the pharmaceutical industry in the manufacture and distribution of pharmaceuticals containing radioisotopes. The AEC has also turned over to private industry the following related services:

(*a*) Synthesis and marketing of C–14 labeled organics;
(*b*) Cobalt 60 encapsulation services;
(*c*) Cobalt 60 gamma irradiation services.

The foregoing demonstrates the way AEC policy has been carried out when private industry is ready to produce or perform services at reasonable prices.

The statement is made that the demand for certain radioisotopes is now at a level which makes commercial production feasible. The five leading revenue producers are:

Fiscal year 1959 [1]

	Thousands
Cobalt 60	$659
Iodine 131	325
Phosphorus 32	171
Polonium 210	208
Carbon 14	263
Total	1,626

[1] Includes research discounts of about $207,000 granted to users under the AEC radioisotopes research support program.

These five radioisotopes represented 65 percent of AEC's dollar sales. All except cobalt 60 require radiochemical processing with attendant high investment in plant facilities. Indications until recently have been that the volume of sales is not sufficient to attract private capital. In fact, the Commission has cooperated with a number of private companies who have made very detailed

examinations of AEC isotope production activities and the commercial opportunities for undertaking the total isotope program. These private groups did not find the market to be sufficiently attractive for a commercial venture involving the total program. It has only been within the last few months that the Commission has received concrete evidence of private interest and intention to produce isotopes. We understand that two existing commercial test reactors are irradiating cobalt, and that one commercial company is considering production and distribtuion of iodine 131 to be produced in another company's irradiation facilities. Power reactor operators have thus far indicated no interest in producing radioisotopes.

The nature and extent of private interest in the production of cobalt 60 is being explored. Industry plans will be taken into consideration in determining the Commission's future plans to meet requirements, particularly for megacurie sources. One of the objectives of AEC is to develop large scale uses for radioisotopes. Success in this objective is dependent on solving technical problems, achieving large-scale availability, and lowering prices. When this objective is reached, the demand for radioisotopes should be at a high enough level to attract private capital and make commercial production of a wider variety of radioisotopes economically feasible.

X. MISCELLANEOUS SERVICES

Film badge processing

C. of C. VI–5: "Servicing of film badges by AEC contractors."

NAM Clf: "Furnishing of film badge service for personnel monitoring. Although a number of industrial firms offer this service, competing services are performed at Oak Ridge, Brookhaven, Savannah River, Sandia, etc."

Servicing of film badges at most AEC installations is regarded as an integral part of the operating procedures established to protect the health and safety of employees. The processing and reading of film badges is intimately related to interpretation and other steps in a monitoring system. Wherever radiation exposure could reach dangerous levels or where personnel must work in radiation zones, quick detection and rapid estimation of exposure are needed for both personnel protection and control of operations; any time delay involved in relying on a commercial contractor to provide these services is unacceptable.

One AEC contractor engaged in the processing of unirradiated source materials is understood to be considering the use of commercial film badge servicing. Another, responsible for operation of an AEC laboratory, is giving serious consideration to canceling its commercial contract in favor of a return to doing its own film badge work because of several years of unsatisfactory experience with inaccuracies and errors on the part of two commercial contractors.

Printing

C. of C. VI–9: "Printing facilities at Government facilities."

Except for the printing establishment maintained for the production and dissemination of scientific and technical reports by the Technical Information Services Extension at Oak Ridge, AEC printing facilities are an integral part of the administrative support for routine management and operation at each AEC installation. Day-to-day operational needs are characterized by large numbers of short production runs with short leadtime.

Provisions of printing equipment for an AEC installation requires prior authorization by the Congressional Joint Committee on Printing, which periodically reviews production reports to assure that equipment continues to be needed. Typically, AEC installations procure from commercial sources a large volume of unclassified printing when large production runs are involved and leadtime permits.

Transportation

C. of C. VI–10: "Operation and maintenance of automotive equipment and transportation facilities (bus and rail) at Government installations."

In the provision of automobile service at AEC installations, our contractors operate fleets of Government-owned vehicles of varied types. Where available, vehicles are obtained from Government motor pools. Peakloads are also met by renting equipment. Automobile service at most AEC installations is an integral supporting activity which can be provided most efficiently by the operating contractor rather than an outside commercial source.

At AEC installations which are in relatively isolated or rural locations, servicing and maintenance of motor vehicles are generally performed in AEC repair shops. There are, however, many locations where reliance on commercial shops and facilities is the practice because it has been found to be practical and more economical.

Bus transportation is provided by our operating contractors at some major AEC installations. Because of the isolation of these facilities, experience demonstrates that commercial bus service cannot be provided on a paying basis, and operating conditions make it impractical to contract for such services at a reasonable cost.

Intraplant railroad service is performed at several installations by AEC operating contractor. At Oak Ridge prior to 1956, the plant railroad was operated under contract by one of the major railroad companies. Cost studies prompted the AEC to transfer responsibility for maintenance and operation of the plant railroad to its operating contractor. Since 1956 the estimated cost has been less than one-third of the minimum amount payable under the earlier contract with the railroad company.

In general, intermittent low-volume operations within our plant sites, often involving special equipment and handling, are best performed as a part of the integrated responsibility of the plant operating contractor.

Power distribution

C. of C. VI–11: "Power distribution in connection with Government installations."

Electric power distribution systems at AEC installations are operated in accordance with the normal industrial practice under which the consumer owns and operates the distribution system beyond the point of delivery, usually the high side of the initial stepdown transformer.

Generally, responsibility for the distribution of electric power within an AEC installation is such an integral part of the overall responsibility of the operating contractor for carrying out the principal mission of the installation that a separate contract for power distribution services could not be tolerated.

A special situation exists at Las Alamos, where many private residences are served from the distribution system. The feasibility of eventually disposing of that part of the distribution system which serves the town facilities is now being studied.

Communication

C. of C. VI–12: "Communications systems at Government installations."

Telephone, teletype, and radio communication equipment is regularly used by AEC installations. Only recently has it become possible to obtain radio equipment on a lease-maintenance basis from commercial sources, and substantial quantities of radio equipment are being secured under such arrangements.

Essentially all teletype facilities used by the AEC are leased from public utilities such as American Telephone & Telegraph Co., Western Union Co., and Radio Corp. of America. Teletype traffic of AEC is processed over networks and tielines provided by public utilities as well as over the military and other Government networks.

Nearly all AEC telephone service is provided by public utilities such as the American Telephone & Telegraph Co., Bell Telephone Cos., and independent telephone companies.

The notable exception is at Hanford, where during World War II a Government-owned telephone system was built because the local telephone company could not undertake to serve so large a site. Major portions of the Hanford system, serving the business and residential areas, were sold to a public utility. Those portions directly and exclusively serving the Hanford plant areas are still owned by AEC and operated by the AEC prime contractor.

Previous analyses have indicated that the present arrangement is more economical than would be the purchase of the service from a telephone company under the rates established for that geographical area. Further studies will be made.

Machine-shop facilities

C. of C. VI–13: "Machine-shop facilities at the Argonne National Laboratory."

Machine-shop jobs are performed in the Argonne National Laboratory's own central shops when (1) there is urgency to complete the job, (2) private companies are not able to perform the work, and (3) shop fabrication must be

carried out coincident with design, development, and proof-testing of the apparatus being built. When these factors are not present, it is the policy of the Laboratory to order the work from private enterprise.

Over recent years steps have been taken to develop commercial sources for metal fabrication having the qualifications and experience to perform the type of work generated by the Laboratory. A large number of qualified companies is now available.

BIG CHIEF DRILLING CO.,
Oklahoma City, Okla., December 7, 1959.

Mr. JOHN A. MCCONE,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE: The Chamber of Commerce of the United States and its committee on commercial uses of atomic energy have been and continue to be vitally concerned with the degree to which the activities of the Atomic Energy Commission are directed so as to "strengthen free competition in private enterprise" as stated in the opening declaration of the Atomic Energy Act. Our meetings with you and your associates at the Commission have been extremely valuable in this connection and we look forward to meeting with you again on January 27, 1960.

We have given a great deal of thought and study to the recent Bureau of the Budget Bulletin No. 60–2 "To the Heads of Executive Departments and Establishments" on the subject of "Commercial-industrial activities of the Government providing products or services for governmental use." We are convinced that Atomic Energy Commission acceptance and implementation of the policy stated in Bulletin No. 60–2 and the review of its commercial-industrial activities will go a long way to "strengthen free competition in private enterprise."

As a result of our interest in Bulletin No. 60–2, I appointed a subcommittee on Government competition with industry of our committee on commercial uses of atomic energy. This subcommittee was assigned the responsibility of compiling specific examples of Government competition with industry in the atomic energy program that the national chamber has received from its members.

I am transmitting, with this letter, a listing of our subcommittee on Government competition with industry and some specific examples of commercial-industrial activities of the Government in the atomic energy program. We believe that a detailed evaluation of such cases is warranted under the terms of Bulletin No. 60–2. We hope that a public statement of the results of such a review will be made as a contribution to clarifying Government policy in this area. We expect to communicate additional examples to you in the near future.

We recognize and are pleased with the progress made by the Commission in reducing some of its activities which compete with industry and submit the enclosed examples in an attempt to assist in furthering this process. We know, from our constructive relationship with the Commission, that we share the basic belief that a strong atomic energy industry will be of great benefit to the American public and practices which retard progress in this area will be costly to the public.

We will be happy to discuss the enclosed examples with you and your associates and trust that we can be of further service to the Commission in connection with the objectives of Bulletin No. 60–2. We would appreciate your keeping us informed of the Commission's activity in this area and hope to discuss the matter with you when you meet informally with our committee on commercial uses of atomic energy.

Sincerely yours,

JACK H. ABERNATHY,
Chairman, Committee on Commercial Uses of Atomic Energy,
Chamber of Commerce of the United States.

CHAMBER OF COMMERCE OF THE UNITED STATES OF AMERICA

COMMITTEE ON COMMERCIAL USES OF ATOMIC ENERGY

SUBCOMMITTEE ON GOVERNMENT COMPETITION WITH INDUSTRY

Frank K. McCune, subcommittee chairman, vice president, atomic business development marketing services, General Electric Co.

Howard Cadwell, president, Massachusetts Electric Co. and vice president, Yankee Atomic Electric Co.
Dr. V. L. Parsegian, dean, School of Engineering, Rensselaer Polytechnic Institute.
James M. Phelan, president, Nuclear-Chicago Corp.
Dr. Philip N. Powers, president, Internuclear Co.
Dr. Chauncey Starr, vice president, Atomics International.
Edwin Vennard, vice president and managing director, Edison Electric Institute.
Charles H. Weaver, vice president, Westinghouse Electric Corp.
George M. Wunder, manager, Nuclear Metals Division, National Lead Co.

EXAMPLES OF COMMERCIAL-INDUSTRIAL ACTIVITIES OF THE GOVERNMENT IN THE ATOMIC ENERGY PROGRAM WARRANTING DETAILED EVALUATION UNDER THE TERMS OF BUREAU OF THE BUDGET BULLETIN NUMBER 60–2

I. Fuel element fabrication

Substantial industrial capability in this area now exists going all the way from mining to the fabrication of reactor cores (except for enrichment processing). Activity in production fuel element fabrication at Government-owned facilities should cease unless it is clearly demonstrated that, in a particular instance, capable commercial fabricators cannot undertake the responsibility. Government laboratories and facilities have and are continuing to fabricate fuel elements for various research, testing, military, and production reactors which could and should be procured from industry. Specific examples which warrant review in accordance with the above policy and Bulletin No. 60–2 have been submitted by members of the National Chamber. The following are some of these specific examples:

1. The Oak Ridge National Laboratory makes the fuel elements for most of its reactors. Examples include the bulk shielding reactor and the LITR.
2. The conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Lomas, San Diego, Calif.
3. The conversion and fabrication of the fuel elements for the nuclear-rocket program (Project Rover).
4. The Savannah River site makes some fuel elements for its reactors. Savannah River is also doing fuel element development work. This includes the conversion and fabrication of fuel elements for the heavy water components test reactor being built at Savannah River.
5. Fuel elements for the Hanford site are fabricated in Government facilities.

II. Research and development

Research and development work should be conducted in private facilities, except where it is clearly demonstrated that such are unavailable for a particular job. The policy of the Government should be to fully utilize and encourage the growth of industrial capacity rather than according preference to Government facilities. Some specific examples, in this area, which warrant review under the above policy and Bulletin No. 60–2 are:

1. Oak Ridge National Laboratory's design of a high-flux isotope producing reactor.
2. Brookhaven National Laboratory's preliminary design of the beam research reactor.
3. Oak Ridge National Laboratory's title 1 and title 2 design of ORR.
4. Argonne National Laboratory's title 1 and title 2 design of hot cells for its new research laboratory.
5. Sandia and Los Alamos design work for the Sandia test reactor.
6. The Government's University of California Radiation Laboratory's design, test and fabrication of nuclear ramjet engines.
7. Argonne National Laboratory's title 1 design of the process heat reactor.
8. Knolls Atomic Power Laboratory's work on a national circulation reactor for the Navy.
9. Los Alamos' experimental work on thermionic cells to convert fission energy directly to electricity.

10. Oak Ridge National Laboratory's Instrument Development Section which in some instances is working on the development of instruments in competition with commercially available equipment.

11. Argonne National Laboratory's development of the Army low-power reactor.

12. Each of the major Government projects have developed their own, and different: hand and foot monitors, scalers, survey meters and multichannel radiatin analyzers in competition with commercially available equipment.

III. Depleted uranium

Essentially all areas of depleted uranium use could be supplied by industry. The following are examples of Government activities in this area warranting review:

1. Conversion of enriched and depleted uranium from UF_6 as required in the "Nuclear Navy" for metal, alloys, or uranium compounds.

2. Depleted uranium metal for an AEC shielding cask project at Schenectady.

IV. Production of radioactive isotopes

The Government is currently producing certain radioactive isotopes in a commercial way (e.g. cobalt 60, iodine 131, carbon 14, sulfur 35, phosphorous 32). The demand for these radioactive isotopes is now at a level which makes commercial production feasible and commercial facilities exist which should be utilized.

V. Irradiation services

Preference should be accorded private irradiation facilities in place of the current preference for loading Government facilities first. This is the best way of encouraging more private capacity. Underloaded commercial facilities exist whereas it is our impression that the Government-owned facilities are heavily loaded. AEC's practice of offering space in the Government-owned MTR and ETR should be limited to only those specific cases where private facilities are unavailable.

VI. Supply of various materials, products, and services

Adequate industrial facilities currently exist to produce and supply many materials and services needed by the AEC that are now secured from Government facilities (both Government and contractor operated). The following are some examples warranting review:

1. Enriched uranium and/or pellets for the gas cooled reactor project at the Oak Ridge National Laboratory.

2. Enriched uranium for the nuclear ramjet project.

3. Enriched uranium metal and/or fabrication for the new Hanford production reactor.

4. Supply and/or fabrication of high purity cobalt for the high intensity radiation development laboratory at the Brookhaven National Laboratory.

5. Servicing of film badges by AEC contractors.

6. Instrument production work at Los Alamos, Oak Ridge, and the University of California (Berkeley).

7. Chemical processing of cold industrial scrap.

8. Supplying AEC's needs for thorium alloy, thorium oxide, thorium carbide, high purity cobalt, and radioisotopes.

9. Printing facilities at Government facilities.

10. Operation and maintenance of automotive equipment and transportation facilities (bus and rail) at Government installations.

11. Power distribution in connection with Government installations.

12. Communications systems at Government installations.

13. Machine shop facilities at the Argonne National Laboratory.

VII. Reprocessing of irradiated fuel elements

It is recognized that the reprocessing of irradiated fuel elements represents an area that is difficult to assess commercially. However, there is no reason to believe that many chemical firms could not handle the job if pricing, regulatory, and load problems could be successfully met. While the Government is spending large sums on developing new processes which inhibit industrial investment in known processes it can speed the transition toward a desirable commercial mode of operation by making maximum use of industrial firms in research and development and possibly the construction and operation of reprocessing plants.

VIII. Atomic electric power

Government competition with the private power industry through atomic electric power continues to be of major concern to us. We were pleased to receive the Commission's response to the national chamber's atomic energy industry policy statement indicating essential agreement with us in this area. We would like to take this opportunity to repeat a small segment of that statement relating to atomic electric power which we feel is essential in this connection:

"The Federal Government should not own or operate atomic powerplants for commercial energy production. Aside from regulation, Government activity in the area of atomic power generation should be limited to research, development, experimentation, and the encouragement of wide industrial participation. As soon as the stated purpose of any Government experimental facility has been achieved, it should be disposed of. Should any Government experimental facility have a residual economically feasible use, it should be offered for sale. The production for sale to the public of electricity generated by means of atomic power should be the responsibility of the existing utility industry. Any interim production of atomic energy by experimental facilities at Federal Government atomic energy installations should either be used by the Government in the operation of such installations or disposed of on a nonexclusive basis to distributing utilities in the area without preference or discrimination."

NATIONAL ASSOCIATION OF MANUFACTURERS
OF THE UNITED STATES OF AMERICA,
New York, N.Y., December 9, 1959.

To Members of the Nuclear Energy Committee.

DEAR COMMITTEE MEMBER: I am sure you will be interested in the enclosed letter to the Chairman of the Atomic Energy Commission concerning AEC activities which could be considered as competition with industry.

This letter is the result of information furnished by the nuclear energy committee in response to Mr. Fairman's request of November 10 for specific areas of competition. The task force also met with representatives of the U.S. Chamber of Commerce and Manufacturing Chemists' Association to discuss a coordinated industry approach to the AEC.

We appreciate the assistance furnished by the committee members and as Mr. Fairman indicates in the last paragraph of his letter to Mr. McCone, we should appreciate other instances of similar activities to be brought to our attention.

Sincerely yours,

STEPHEN P. COBB, Jr.,
Committee Executive, Nuclear Energy Committee.

NATIONAL ASSOCIATION OF MANUFACTURERS
OF THE UNITED STATES OF AMERICA,
New York, N.Y., December 4, 1959.

Mr. JOHN A. MCCONE,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MCCONE. A special task force of our nuclear energy committee has reviewed in considerable detail activities in the nuclear energy field as they might come within the scope of Bureau of the Budget Bulletin 60–2. This letter outlines the results of the initial deliberations of that group.

The Atomic Energy Act of 1954 states in chapter 1, section 1b that, among other objectives, it shall be the policy of the United States to use atomic energy to "strengthen free competition in private enterprise." We believe that Congress intended that the full strength of the private enterprise system be brought to bear on the development of a healthy, competitive nuclear industry. Your stated policy as Chairman of the AEC has reemphasized that point on numerous occasions.

We recognize that the situation existing today is considerably different from that which existed at the time of the passage of the 1954 act. At that time, industry was just entering the nuclear field and needed technical assistance from the AEC. Today industrial capability has greatly increased and there are a number of areas in which the AEC is operating programs in Government-owned facilities which are in direct competition with industry.

It is our fundamental belief that in the area of civilian programs, Government-owned facilities should be used only for research and development activities requiring special facilities which do not exist in industry. However, insofar as possible, activities should be carried on by privately owned facilities, financed with private funds.

From this fundamental viewpoint, the special task force outlines below several areas of special competition:

A. Fuel cycle

(1) There is a substantial existing private industry to process uranium from the mine to fabricated reactor cores with the exception of the uranium 235 enrichment process. Everywhere that the Government operates in its own facilities in this area, with the noted exception, there is direct competition with industry.

(*a*) Conversion from UF_6 and fabrication of fuel elements for AEC nuclear rocket program at Livermore; for subcritical training reactors; for heavy water components test reactor, Savannah River; for process heat reactor to be built at Point Lomas, Calif.

(*b*) Supply of enriched uranium oxide, pellets, or metal for gas-cooled reactor project; ETR and MTR at Arco, Idaho; NPR at Hanford; and all uranium alloys or compounds for the "nuclear navy."

(2) Government-owned laboratories are fabricating depleted uranium into shielding casks and other forms for reactor projects. Private industrial capability exists for such operations.

For example:

(*a*) Supply of blanket fuel elements for zero power reactor at Argonne National Laboratory.

(*b*) Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field.

(*c*) Supply of depleted metal for shielding cask project at Schenectady.

(3) In the area of reprocessing of irradiated fuel elements, the Government can and should greatly aid in the transition to a commercial mode of operation by making maximum use of industrial groups in process research and development and in construction of, and operations related to, reprocessing plants. To promote the growth of a healthy industry in this area, Government funds should be used to finance research and development programs in privately owned facilities in preference to Government-owned facilities.

B. Irradiation services

The AEC should announce a policy to utilize privately owned reactors for materials testing to the extent that industry is able to provide space. This use of private reactors should be in preference to the use of a similar Government-owned facility. The current use of MTR and ETR for Government-sponsored research, which constitutes the great majority of the materials testing business, results in severe competition for the private test reactors.

C. Supply of other materials and services

(1) There are industrial facilities available with the capacity to furnish practically all special materials and services; these should be used in preference to Government-owned facilities.

For example:

(*a*) Supply of thorium oxide for homogeneous reactor development at ORNL.

(*b*) Supply of thorium metal for special projects at Los Alamos, Sandia, Lawrence Radiation Laboratory at Livermore.

(*c*) Supply of high purity cobalt for High Intensity Radiation Development Laboratory, Brookhaven.

(*d*) Design, construction, and testing of reactors, reactor prototypes, and reactor experiments for which industrial capacity and capital exists.

(*e*) The first reactor in the Army low power reactor program was fabricated by an industrial concern at its own facilities, but the second will be fabricated in a Government-owned facility.

(*f*) Furnishing of film badge service for personnel monitoring. Although a number of industrial firms offer this service, competing services are performed at Oak Ridge, Brookhaven, Savannah River, Sandia, etc.

(*g*) Personnel radiation monitors are developed and produced in instrument production sections at Government-owned laboratories. There is an

instrument industry capable of furnishing such monitors and it should be used.

(*h*) Government construction of radiation measuring equipment is also in direct competition with the private instrument industry.

To reiterate my opening comment, programs in the nuclear field should be carried out in privately owned facilities wherever possible. Government-owned facilities should be used only for research and development projects for which equipment is not available in industry.

We trust these comments will be of value in connection with your consideration of Bureau of the Budget Bulletin 60–2. As time goes on, there may be other instances of similar activities which come to our attention and we should welcome the opportunity to discuss them with you as the occasion arises.

Sincerely yours,

J. F. FAIRMAN,
Chairman, Nuclear Energy Committee.

MANUFACTURING CHEMISTS' ASSOCIATION, INC.,
Washington, D.C., December 2, 1959.

Mr. CHARLES G. MANLY,
Assistant Director for Commercial Activities,
U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. MANLY: At the meeting of the Manufacturing Chemists' Association Nuclear Committee on October 15, which you, General Luedecke, and Ed Bloch attended, there was a discussion of private industry's ability to supply materials and services required by some of the AEC-sponsored projects.

In order to have some concrete examples, we canvassed the members of the committee. One or more member companies have stated that they have the technical capability and existing production facilities for supplying materials and services included in the attached list. At the present time, we are checking to determine the total production capacity for each item and will supply you with this information at a future date.

Since these projects are nonroutine in nature and are not part of the Commission's plutonium or weapons program, it is felt that the materials and services could be supplied by industry without disturbing the Commission's routine operations.

If you desire any further information on this subject, please let me know.

Sincerely,

R. C. JOHNSON.

AEC SPONSORED PROJECTS FOR WHICH MCA MEMBER COMPANIES HAVE TECHNICAL CAPABILITIES AND PRODUCTIVE CAPACITY

1. Conversion of all enriched and depleted uranium from UF_6 as required in the "Nuclear Navy" for metal, alloys or uranium compounds.
2. Depleted uranium for all activities at the national laboratories with specific attention directed to the conversion of depleted uranium from UF_6 and the fabrication of blanket fuel elements for the zero power reactor at Argonne National Laboratory.
3. Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field representing approximately 40 tons of cylindrical casting.
4. Conversion and fabrication of fuel elements for the process heat reactor project to be built at Point Loma, San Diego, Calif.
5. Enriched uranium oxide and/or pellets for the gas-cooled reactor project at ORNL.
6. Conversion and fabrication of fuel elements for the AEC's nuclear rocket program at Livermore.
7. Supply of enriched uranium metal for ETR and MTR fuel elements.
8. Enriched uranium metal and fabrication of fuel for the NPR at Hanford.
9. Depleted uranium metal for AEC shielding cask at General Electric, Schenectady.
10. Supply and/or fabrication of high purity cobalt for the high intensity radiation development laboratory at the Brookhaven National Laboratory.

11. Production of uranium for heavy water components test reactor being built at Savannah River.
12. Conversion and fabrication of uranium elements required for subcritical training reactors for educational institutions.
13. Production of enriched uranium metal for the Piqua and Hallem reactors.
14. Supply of thorium oxide for the homogeneous development program at ORNL.
15. Supply of thorium metal for special projects at Los Alamos, Sandia, and Lawrence Radiation Laboratory at Livermore.
16. Recovery of cold fabrication scrap, both high and low enriched, from all of the above projects.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., December 17, 1959.

Mr. JAMES T. RAMEY,
Executive Director, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. RAMEY: There are enclosed copies of letters from the U.S. Chamber of Commerce, the National Association of Manufacturers, and the Manufacturing Chemists' Association which set forth activities conducted in Government-owned, contractor-operated facilities of the Commission which they believe should be performed by private industry in accordance with the policy and criteria of Bureau of the Budget Bulletin No. 60–2, "Commercial-Industrial Activities of the Government Providing Products or Services for Government Use."

A staff study is being undertaken of the named activities in order to make a specific reply to these groups. Your committee will be kept fully informed.

Sincerely yours,

A. R. LUEDECKE, *General Manager.*

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., September 21, 1959.

Bulletin No. 60–2.

To: The Heads of Executive Departments and Establishments.

Subject: Commercial-industrial activities of the Government providing products or services for governmental use.

1. *Purpose.*—The purpose of this bulletin is (*a*) to clarify the application of existing policy regarding competition between the Government and private enterprise in the light of executive branch experience under Bureau of the Budget Bulletins No. 55–4 of January 15, 1955, and No. 57–7 of February 5, 1957, and (*b*) to provide for the evaluation of all commercial-type enterprises not previously reviewed. To make this program more manageable, procedures have been designed to simplify reporting and to permit agencies to direct their major attention to those activities of greatest significance and budgetary impact.

2. *Policy.*—It is the general policy of the administration that the Federal Government will not start or carry on any commercial-industrial activity to provide a service or product for its own use if such product or service can be procured from private enterprise through ordinary business channels.[1]

3. *Exceptions.*—Because the private enterprise system is basic to the American economy, the general policy establishes a presumption in favor of Government procurement from commercial sources. This has the twofold benefit of furthering the free enterprise system and permitting agencies to concentrate

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[1] "Commercial-industrial activity * * * for its own use" includes the provision of services or products primarily for the use of a Government agency (whether the providing agency or other agencies), but excludes, for the purpose of this bulletin, activities producing a service or product primarily for the public or agency employees. Also excluded are functions which are a part of the normal management responsibilities of a Government agency or a private firm of comparable size (such as accounting, personnel work, and the like). In determining whether an activity is "commercial-industrial" in nature and "can be procured from private enterprise through ordinary business channels," reference may be made to the "Standard Industrial Classification Manual" (available from the Superintendent of Documents, U.S. Government Printing Office). Additional information about both source and ability of private enterprise to provide a product or service may be secured from the Business and Defense Services Administration of the Department of Commerce.

their efforts on their primary objectives. However, in specific situations certain factors may make it necessary or advisable for a Government agency to produce goods or services for its own use. In these situations the burden of proof lies on the agency which determines that an exception to the general policy is required. A finding must be made that there are compelling reasons for Government provision of a product or service before an exception is authorized. All relevant factors must be taken into account, including pertinent economic and social aspects of public policy, even though they may not be the immediate concern of the agency or official directly responsible for the particular activity.

Compelling reasons for exceptions to the general policy include national security; relatively large and disproportionately higher costs; and clear unfeasibility. Each of these is discussed below.

A. *National security.*—"National security" as a compelling reason for continued Government ownership and operation of an activity is not meant to be all inclusive of all products or services with restricted classifications. Commercial contractors operating under proper security clearances and safeguards have been, and should continue to be, essential to the national defense effort. There are instances, however, when for reasons of national security, an activity cannot be turned over to private industry. These activities may include, but are not necessarily limited to, functions which must be performed by Government personnel in order to provide them with vital training and experience for maintaining combat units in readiness.

B. *Costs.*—Continuation of Government operation on the ground that procurement through commercial sources would involve higher costs may be justified only if the costs are analysed on a comparable basis and the differences are found to be substantial and disproportionately large. In such cases, the costs of both Government operation and private procurement must be fairly computed and complete. The costs assigned to Government operation must cover all direct and indirect outlays, such as pay and other allowances for personal services and leave; contributions for retirement and disability; supplies; materials; transportation; warehousing; utilities; maintenance; repairs, and similar factors. Appraisal of elements not usually chargeable to current appropriations, such as depreciation, interest on the Government's investment,[2] the cost of self-insurance (even though it is unfunded), and exemption from Federal, State, and local taxes[3] must also be made to the extent necessary to put the costs on a comparable basis. On the other hand, costs attributed to procurement from private sources must be computed on an equally fair and complete basis. They should be truly representative of the lowest price the Government would pay for the quantity and quality needed, taking into account all applicable costs of the Government for such procurement, and costs of handling and delivery.

The admissibility of relatively large and disproportionately higher costs as a possible compelling reason for continued Government operation does not alter the general policy which establishes a presumption in favor of Government procurement from commercial sources and does not prohibit procurement from more costly commercial sources. For instance, it may be found to be in the public interest to purchase the product or service, regardless of cost factors, in order to foster or maintain the development or growth of commercial production capabilities to meet ultimate governmental and nongovernmental needs at potentially lower costs.

The existence of Government-owned capital assets is not in itself an adequate justification for the Government to provide its own goods or services. The need for continued Government ownership or operation must be fully substantiated. In many instances, evaluation may show that excessive operating costs, obsolescence, replacement costs, or low rates of utilization make continued Government operation unwarranted and liquidation of the asset preferable. Similar examination should be made of any reasons that tend to substantiate a compelling need for continued Government ownership and operation. Even the operation

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[2] Initial costs may be used for determining the value of the Government's investment. However, if the initial costs are no longer valid for purposes of a cost analysis, the estimated current fair market value may be used instead.

After having determined the value of the Government's investment in the activity, the interest cost should be computed by using the current average market yield of outstanding marketable obligations of the United States having maturities comparable to the useful life of the item.

[3] Benchmarks for estimating taxes may be obtained from tables 1 and 3, "Statistics of Income, 1956–57, Corporation Income Tax Returns," Publication No. 16, U.S. Treasury Department, Internal Revenue Service.

of a Government-owned facility by a private organization through contractual arrangement does not automatically assure that the Government is not competing with private enterprise. This type of arrangement could act as a barrier to the development and growth of competitive commercial sources and procurement through ordinary business channels.

C. *Clear unfeasibility.*—Certain products or services may be found to be clearly unfeasible to procure from private enterprise through ordinary business channels due to the fact that the product or service is—

(1) An integral function of the basic mission of the agency, or

(2) Not available in the particular instance, nor likely to become available commercially in the foreseeable future because of the Government's unique or highly specialized requirements or geographic isolation of the installation, or

(3) Administratively impractical to contract for commercially.

4. *Scope of evaluation.*—Each agency shall—

A. Make an evaluation and report of all its commercial-industrial activities not evaluated under Bureau of the Budget Bulletin No. 55–4 or 57–7. This should include activities which are Government owned, contractor operated, and those which were established after December 1956.

B. Report the current status of those activities which were evaluated previously under Bulletin No. 55–4 or 57–7, including new starts established prior to December 31, 1956.

To permit speedy evaluation of commercial-industrial activities warranting detailed review and analysis, agencies may indicate their intention to eliminate from all extensive evaluation those activities which must be continued, in whole or in part, because it is clearly unfeasible to procure the products or services from private enterprise through ordinary business channels as defined in paragraph 3C.

When continued Government operation of an activity is determined to be mandatory in the public interest because of one of the compelling reasons enumerated in paragraph 3, such operation should be at a reasonable level of efficiency and economy.

5. *Prompt and orderly action in termination or curtailment.*—Activities which are not authorized as an exception to the general policy because of a compelling reason should be discontinued as soon as reasonably possible. Similarly, activities which are to be curtailed should have their operations reduced as speedily as possible.

Each agency should exercise diligence in carrying out such actions in an orderly way and should proceed on a reasonable time schedule. Adequate notice should be given to the community and employees in advance of discontinuance or curtailment, and each agency should assist employees as necessary in finding other employment. Where statutory changes would be necessary to permit discontinuance or curtailment, the agency head should seek such changes promptly, submitting drafts of legislation or appropriation language, as may be required, to the Bureau of the Budget in the usual manner.

6. *Steps to be taken before establishing new activities.*—No new commercial-industrial activity shall be started until the responsible official has made a formal finding for the record that, due to one of the compelling reasons stated in paragraph 3, Government provision of the product or service is in the public interest. Proposed starts should be subject to the same review outlined in this bulletin for the evaluation of existing activities.[4]

7. *Reports.*—The forms are designed for the evaluation of existing and newly established activities not evaluated previously, and to serve as a basis for review of the current status of activities evaluated previously under Bulletin No. 55–4 or 57–7. Instructions for subsequent progress will be issued at a later date. It is intended that future reporting will be limited generally to activities (*a*) whose status has changed since their previous evaluation; (*b*) for which substantiating data on agency determinations have been requested by the Bureau of the Budget; or (*c*) which have been newly established since July 31, 1959.

Three types of reports are to be submitted. Paragraphs 7A and 7B apply to commercial-industrial activities established prior to December 31, 1956. The total number of installations and activities in these summary and individual

[4] Establishment of new activities includes the establishment, acquisition, or reactivation of any commercial-industrial activity, regardless of the annual estimated cost or value of the product or service.

reports should equal the total number of installations and activities listed in the "Inventory of Certain Commercial-Industrial Activities of the Government",[5] plus those new starts previously reported to the Bureau of the Budget in accordance with Bulletin No. 57-7. Any differences should be explained.

Those commercial-industrial activities established during the period of January 1957 through 1959 are discussed in paragraph 7C.

A. Summary evaluation reports of actions and decisions to discontinue, curtail, or continue commercial-industrial activities will be made according to exhibit 60-2A (copy attached), if the annual estimated cost or value of the product or service is less than $250,000.

Part I applies to activities previously evaluated in accordance with Bureau of the Budget Bulletin No. 55-4 or 55-7. Part II applies to activities newly evaluated in accordance with Bureau of the Budget Bulletin No. 60-2.

B. Individual evaluation reports of actions and decisions to discontinue, curtail, or continue commercial-industrial activities will be made according to exhibit 60-2B (copy attached), if the annual estimated cost or value of the product or service is $250,000 or more.

Part I applies to activities previously evaluated in accordance with Bureau of the Budget Bulletin No. 55-4 or 57-7. Part II applies to activities newly evaluated in accordance with Bureau of the Budget Bulletin No. 60-2.

C. Individual reports of commercial-industrial activities established from January 1957 through July 1959, regardless of the annual estimated cost or value of the product or service, will be made according to exhibit 60-2C (copy attattached.

Two copies of each report shall be submitted to the Bureau of the Budget on or before December 31, 1959. Negative reports should be submitted if appropriate. Detailed substantiating data need not be submitted, but the agency should be prepared to justify its findings.

No reports need be submitted for activities, other than transportation, conducted outside the States of the Union and the District of Columbia.

Up to 50 copies of these report forms may be obtained from the Bureau of the Budget Publications Unit, code 113, extension 2333; if more copies are needed, the agencies should have them reproduced.

8. *Delegation.*—The agency head may delegate to officials within his agency his responsibility for decisions and findings on activities with an annual estimated cost or value of product or service of $1 million or less. In such cases, the one to whom such authority has been delegated must sign the report. No delegation may be made to the official immediately responsible for producing the product or service.

9. *Dissemination of policy.*—The agency head should take appropriate steps to ensure that responsible officials in his agency are familiar with this bulletin and with the need for continuing review and evaluation. When needed, agency heads shall develop and issue specific instructions and criteria to supplement this bulletin.

10. *Agency responsibility for continuing review.*—Although this bulletin does not deal with products or services provided primarily to the public or agency employees, each agency shall keep such activities under continuing review and evaluation to determine if such products or services can be procured from private enterprise through ordinary business channels.

Similarly, although this bulletin calls only for action and reports on certain commercial-industrial activities conducted by the Government for its own use, agencies are expected to review all commercial-industrial activities on a continuing basis.

By direction of the President:

MAURICE H. STANS, *Director.*

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[5] Issued by the Bureau of the Budget in May 1956.

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